JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 24 APRIL 15, 1934 No. 4

BOTANY.—*The problem of arctic vegetation.*[1]

ROBERT F. GRIGGS, George Washington University.

One of the most definite of the side lines which I expected to carry through when the National Geographic Society sent me to Katmai was a study of the vegetation of the region—that is of the normal vegetation outside the area devastated by the great eruption of 1912.

But when I tried to classify the vegetation on the ground as it would be done by an ecologist further south, I became confused and had to give it up. It was easy to segregate the plant societies in a few special situations like the strand and the dunes. But these were all habitats of minor importance, and after they had been considered the main body of the vegetation remained hopelessly confused. Five times upon returning to the States, I renewed the determination to master the problem on the next trip. And every time until the last I gave it up as beyond my power of generalization.

This may sound strange in view of the fact that many others before me have studied arctic vegetation and have published voluminous records of what they observed. I shall return to a brief consideration of the literature, but at this point I may say merely that earlier students had not, to my mind, solved the problem of dealing with arctic vegetation. All of them have attempted to treat arctic ecology from analogy with the ecology of temperate regions. But high latitudes are different from low latitudes and analogies break down. I felt that a new point of view was essential to effective treatment of the problem and until this was gained nothing could be accomplished.

DISTINCTION BETWEEN ARCTIC VEGETATION AND ARCTIC FLORA

I should, perhaps, explain the distinction drawn between arctic vegetation and the arctic flora. The student of a flora, a taxonomist,

[1] Address of the retiring president of the Washington Academy of Sciences delivered January 18, 1934. Received February 6, 1934.

is concerned primarily with the species which occur in a region, with the species as separate entities, while the student of vegetation, an ecologist, is concerned primarily with the relations of these species to each other and to their physical environment, as they grow together in the field. The taxonomist stands to the ecologist somewhat as does the nurseryman to the landscape gardener. The work of the taxonomist and the nurseryman must underlie any development of ecology or of landscaping. But as successful planting requires a great deal more than a knowledge of the nurseryman's materials, so an ecological treatment demands very much more than a knowledge of the flora of the area studied.

In the temperate zone vegetation is rather clearly segregated into more or less well-marked associations, like beech forests, oak forests, pine woods, swamps, and bogs. Each of these associations has a somewhat definite composition, and mention of a few plants at once conveys to one familiar with the country a picture of the whole association. Thus when you enter a pine woods hereabout you expect to find spotted pipsissewa and dewberries, but not maidenhair fern, jack-in-the-pulpit or Dutchman's breeches. Study of vegetation types has convinced us, moreover, that these associations are not accidental, but that they arise from causes to be found in the special requirements of the species present interacting with the different conditions of the various habitats.

When one goes to the arctic he naturally expects to find similar plant associations, but instead he meets a bewildering mixture of plants of all sorts jumbled together in seeming defiance of the principles of plant association learned in low latitudes. The criteria by which plant associations are distinguished further south break down in the arctic. In few of the different habitats can characteristic species be named, and most habitats are invaded with some measure of success by almost every species of the flora. The fact that two species happen to be associated in a given situation means nothing as to their habitat preferences—to the utter bewilderment of a botanist accustomed to finding one set of plants in oak forests and another in beech woods. Lacking plant associations in the sense of more or less organic societies with definite constituent species, the vegetation appears an indescriminate mixture of the species of the flora as though the plant cover of any situation depended merely on the seeds that happened by chance to fall thereon instead of on the fitness of the species represented for that particular habitat.

INDIFFERENCE OF ARCTIC PLANTS TO ALTITUDE

A special case of this sort of thing is the indifference of arctic plants to altitude. This has been noted by many observers and in many lands. Whereas in the south we find definite zones of vegetation with the alpine types limited to the highest mountains, nothing of the sort occurs in the arctic. There the sea cliffs and the mountain summits have practically the same flora.

A curious instance of the indifference of plants to altitude in the north, though in this case in a boreal rather than in an arctic country, has recently been brought to light in Newfoundland. There Fernald (1933) has found a large number of high-arctic species reaching their southern limits not on the mountains but on the coast near sea-level. Conversely a number of southern species such as *Schizaea pusilla* of the New Jersey pine barrens, and the orchids, *Habenaria psychodes*, *Calopogon puchellus*, *Cypripedium acaule*, and *Pogonia ophioglossoides* together with *Rynchospora alba*, *Bartonia*, *Utricularia clandestina*, *Xyris* and others, which reach their northern limits in Newfoundland, are to be found not on the lowlands but only on the high tablelands of the interior. The high-arctic element confined to the coast makes an especially impressive showing since the arctic species already collected comprise 49½ per cent of the total flora of the Arctic Archipelago and Fernald thinks that their number would be considerably increased by further collecting.

But arctic vegetation like the arctic flora is similar all around the pole, and it has been described by many observers, especially in Scandinavia. It is instructive to observe the devices used by these writers in the attempt to characterize an indiscriminate vegetation. They fall in general into two categories. Either the accounts are abstractions too far removed from the actual plant cover, or they are merely particularized descriptions of individual patches of plants whose variations are neither in any way correlated with physical factors, nor of general application to other areas.

PRESENT PRACTICES IN DEALING WITH ARCTIC VEGETATION

The Upsala school, which adopts the second course, sets up more than one hundred "associations" to describe a vegetation where there are less than that number of common species. Thus Fries (1913) in northern Sweden lists fifteen lichen-rich heaths as follows: (1) Lichen-rich *Empetrum* association, (2) lichen-rich *Phyllodoce* association, (3) lichen-rich *Azalea* association, (4) lichen-rich *Andromeda tetragona* association, (5) lichen-rich *Andromeda hypnoides* association,

(6) lichen-rich *Salix herbacea* association, (7) liverwort-*Salix herbacea* association, (8) lichen-rich *Dryas octopetala* association, (9) lichen-rich *Diapensia lapponica* association, (10) lichen-rich *Juncus trifidus* association, (11) lichen-rich *Carex rigida-C. lagopina* association, (12) lichen-rich *Hierochloë alpina* association, (13) lichen-rich *Calamagrostis lapponica* association, (14) lichen-rich *Festuca ovina* association, (15) lichen-rich Forb association. Further it is to be observed that a number of the character plants given above appear also as character plants in several other associations, e.g. *Empetrum nigrum* appears in the moss-rich *Empetrum* heath, the *Empetrum*-rich lichen-birch forest, and the *Empetrum* high-moor. Moreover the subordinate plants in each of these associations include to a large extent the character plants of adjoining associations. *Empetrum nigrum* also appears in the plant lists of the following eighteen associations: (1) Heath-like lichen-birch woods, (2) *Myrtillus nigra*-rich lichen birch woods, (3) *Azalea*-rich lichen-birch woods, (4) *Carex rigida* lichen birch woods, (5) *Polytrichum*-rich lichen-birch woods, (6) lichen-rich *Betula nana* bushland, (7) lichen-rich *Diapensia lapponica* association, (8) lichen-rich *Juncus trifidus* association, (9) lichen-rich *Calamagrostis lapponica* association, (10) moss birch woods, (11) mossy *Betula nana* bushland, (12) mossy *Andromeda tetragona* association, (13) mossy *Calamagrostis lapponica* association, (14) *Geranium silvaticum*-rich meadow birch woods, (15) *Cirsium heterophyllum*-rich meadow-birch woods, (16) *Betula nana* high-moor, (17) *Salix glauca* high-moor, (18) *Rubus chamaemorus* high-moor. While it is true that *Empetrum* is probably the most nearly ubiquitous of all the species in the lower arctic regions, yet most of the other common species would make the same sort of a showing.

I must beg the reader's pardon for giving such a jumbled and repetitious list of names. But if left out, the real situation would be grasped only by those who took the trouble to look up the original. Nothing would have been easier for me at Katmai than to have given a similar list of a hundred or more "associations." But however useful such an analysis might be to the writer himself it did not seem to me that it would be very helpful to the ecological fraternity in general.

The difficulty of the problem may be readily visualized from a perusal of Ostenfeld's account of the botany of the Faeröes (1908), which, though lying at a comparatively low latitude, are essentially arctic in character. He works out a clear and logical classification, but he tells us (page 920) that it is "more abstract than in most other

countries and it will be necessary again and again to indicate the gradual transition from one association to another." These transitions (page 935) "recur with almost tiresome frequency and an accurately defined survey is almost impossible." (Page 920) "It will be understood that differences so slightly defined are difficult to maintain," and again (page 981) "The mosses as well as the higher plants convey the same impression, they are a very mixed and heterogeneous company."

VARIABLE HABITAT PREFERENCES OF ARCTIC PLANTS

From the literature also another aspect of the puzzle appeared; not only are the habitat preferences of arctic plants obscure but such as they are they vary from region to region, thus breaking down the few ideas on the subject I had been able to deduce at Katmai. In the "Flag" vegetation of Iceland, according to Hansen (1930), rock-dwelling alpine plants such as *Silene acaulis*, *Saxifraga oppositifolia*, and *Thalictrum alpinum* grow together with aquatics including *Subularia aquatica*, *Triglochin palustris*, and *Ranunculus reptans*—a mixture which passes my imagination even after my experiences at Katmai. Again the Arctic fireweed, *Epilobium latifolium*, which is confined to rock crevices and gravel bars in southern Alaska, in Greenland invades the ponds and pushes creeping runners two to three meters long out into water knee-deep (Rikli, 1910). A third illustration I quote from Simmons (1913), who reports (p. 145) "*Statice maritima*, a pronounced halophyte in the south becomes an inland and mountain plant in the north."

Arctic ecology fairly bristles with anomalies like these, the mere mention of which arouses one's desire to understand them. Probably many of them would be readily explained if they were attacked experimentally. Some day we shall have laboratories as well as field stations in the arctic where such problems may be solved.

DEFINITION OF TUNDRA

Not the least of the difficulties of dealing with arctic vegetation lies in the prevalent confusion as to what constitutes "tundra." Good writers use the term in two distinct senses, some with a geographic, some with a descriptive connotation. Thus the Standard Dictionary defines it as "A rolling treeless plain of Russia, Siberia, and the American arctic regions, covered with moss and at times very moist or marshy." The reason for this ambiguous definition probably lies in a natural desire to convey to persons who have never visited the

arctic some concrete idea of the appearance of the tundra. But the inevitable result has followed. The two meanings will not hold together. The arctic plains are by no means universally boggy, consequently some writers have fixed upon the geographic sense of the word and others upon the descriptive. Then the layman, unaware of the real situation, and endeavoring to gain some idea of the country, re-synthesizes the diverse conceptions and concludes that the whole arctic is a barren moss-covered morass, gaining his ideas of the character of the tundra from those who use the word in a descriptive sense and of its extent from those who use it in a geographic sense. This is the situation which Stefansson has endeavored to set right with his phrase "The friendly arctic" and by his prolonged efforts to portray the possibilities of reindeer and muskox culture in the north.

Clearly enough ambiguity cannot be tolerated in a scientific term. If tundra is to be retained its meaning must be fixed. But unfortunately both senses are thoroughly established in good usage. To Alaskans and to a certain extent to Canadians tundra is nearly synonymous with bog. The forest bogs of southeastern Alaska which differ little from the bogs of Oregon and Washington are called tundras by the people of the country. Such usage is not confined to common parlance but is to be found in scientific literature as well. Witness the following from Summerhayes and Elton's (1928, p. 264) account of Spitzbergen. "Tundra, defined as swamp or moorland, is quite absent from Spitzbergen." Nevertheless much of the "heath" described from Spitzbergen and other parts of the Atlantic province of the arctic is exactly the sort of vegetation which Alaskans would single out as tundra, and thus confusion creeps into the ranks even of those who use the word in a descriptive sense.

Now there are, to be sure, extensive areas of the tundra which are best described to a southerner as boggy, but the larger part of the arctic is arid, and the innermost subpolar areas are more arid than the outer transitional regions. Simmons (1913, p. 31) discussing the ecological conditions of the Arctic Archipelago says "The prominent and important factor I take its extreme dryness to be." The annual precipitation in all high arctic countries is less than 10 inches, a deficiency in rainfall which in lower latitudes invariably marks a desert. It should be pointed out however that much less rainfall is required to support a given type of vegetation in high latitudes than in low. There are several reasons: (1) Evaporation is less on account of lower temperature. (2) The water requirement of a given plant is proportional to the length of the growing season. (3) In parts of the arctic

fog and mist are so prevalent that measurements of collected rainfall do not give a correct idea of the humidity of the climate. (4) Thawing of snow and ground ice keeps poorly drained situations soggy throughout the summer with very little loss by runoff. But after all allowances are made for economy in the utilization of the scanty rainfall the essential fact remains that the arctic is predominantly an arid country and that furthermore the high arctic is more arid than the lower.

It was in the discussion of desert country that the term tundra was introduced to scientific literature by Middendorf (1864). Middendorf found the analog of tundra to be not bog but steppe and went into long and detailed comparisons of tundra and steppe. He found it indeed somewhat difficult to produce satisfactory differentiating characters between the two aside from the plant species concerned. He describes the Siberian tundra as the most extreme desert, "ödste Öde" (p. 736) and states that it is too dry to be compared with any terrain familiar to Europeans. Further, he specifically states that no peat develops in the "high tundra."

Middendorf had a very wide acquaintance with the tundra not only across Siberia but in Russia and Lapland as well. He clearly differentiates the "high tundra" or what we might call desert tundra from "low tundra" which he describes as grassy or boggy. Inasmuch as his account was not only the first, but remains to this day one of the best scientific studies of the tundra I believe that we would do well to follow him and use tundra in a geographic sense, applying it to all of the country of the treeless arctic.

BOUNDARIES OF THE ARCTIC

Another major difficulty lies in the lack of any general agreement as to the proper boundaries of the arctic. Before I could do anything with my own area at Katmai I had to decide whether it was arctic or temperate. Inasmuch as decision on this point would seem to be a prime requisite for further treatment of the subject, I will digress to consider it here.

The reason for the indecision as to the boundaries of the arctic lies partly in the lack of any comprehensive general treatment of arctic ecology and partly in a failure to recognize the fact that the arctic, like any other major vegetation zone, requires subdivision before it can be treated adequately. Explorers of high arctic countries are inclined to tell us that "real arctic conditions" or "true arctic vegetation" is limited to polar lands. It is natural enough for one familiar with Spitzbergen, north Greenland, or Ellesmere Land to

think northernmost Norway temperate by comparison. Thus we find Simmons (1913, p. 144) criticising Hooker's ideas of the Scandinavian arctic, saying "Even the northernmost part of the Scandinavian Peninsula is not an arctic but a temperate land."

There is no difference of opinion as to the facts at issue. No one doubts but that the flora of the arctic Archipelago is far more extreme than that of the North Cape. But if the two are to be assigned to different zones where should a line be drawn between them? From the extreme poverty of the plant life of the polar desert there is the most gradual transition to comparatively luxuriant vegetation like that of arctic Norway. Any boundary separating the two would have to be an entirely arbitrary affair.

It would be natural to call the transitional belt of more luxuriant vegetation surrounding the polar area subarctic. But unfortunately subarctic is well established in another application—to the circumpolar boreal coniferous forest. If we are to follow accepted usage and call the Hudsonian forest subarctic there is no alternative but to denominate as arctic all territory beyond the forest border.

There is really no need of attempting to move the term subarctic from the forest into the outermost belt of the arctic. If we recognize that North Greenland, the northern portion of the arctic Archipelago, and Spitzbergen are "high arctic" as is commonly done, it is a simple matter to term such countries as South Greenland, northern Scandinavia, and northern Alaska "low arctic," and that meets the problem just as well as though we should attempt to limit the "true arctic" to polar areas and reduce the outermost belt to subarctic.

IMPORTANCE OF THE ARCTIC TIMBER-LINE

It will be agreed that the arctic timber-line, the limit of coniferous forest, is one of the major vegetation boundaries of the earth. It is not only clearcut and easy to recognize, but it marks a transition important to life in its every aspect. Whether one thinks of the numerous plants of the undergrowth which find shelter in the forest but cannot grow beyond, of the birds and mammals which almost necessarily have different habits and different adaptations within and without the forest, or of the aboriginal cultures which develop in the possession of timber or in the lack of it—from every point of view the forest border is of fundamental importance. Even more significant from the human standpoint is the fact that the forest border marks approximately the northern limit of cereals and of all sorts of agricultural operations except reindeer grazing.

COMPARISON OF TREE LIMIT AND SUMMER TEMPERATURE

Recognizing that as one progresses toward the pole increasingly severe conditions are encountered and that in a general way the meagerness of polar life is due to the rigor of the climate, it is natural to seek a climatic transition at the timber-line. If one is not too particular about close coincidence of climatic and vegetational lines this may be done, for it may be observed that there is a rough parallelism between the edge of the forest and the July isotherm of 10°C. (50°F.).

But if one examines the case more closely, the discrepancies become somewhat disconcerting. On the Alaska peninsula the forest, which ends at Kodiak, is two hundred and fifty miles behind the isotherm which crosses at the Shumagin Islands. But in northeastern Alaska at about longitude 145° the forest has caught up and the two coincide. East of the Mackenzie near Cape Dalhousie the forest goes nearly one hundred and fifty miles beyond the isotherm. But on the west shore of Hudson's Bay it has fallen back again until it is three hundred and fifty miles below the isotherm. At Ungava Bay in northern Labrador, however, the forest again reaches forward until it is nearly four hundred miles beyond the isotherm which bends far to the south, nearly touching Newfoundland.

In western Eurasia as in western America the forest front, composed now of pines and now of spruces, again lags behind the isotherm by a hundred miles or more. This is true both in humid Norway and in arid Russia. In Siberia both isotherm and forest reach far northward, running probably as closely parallel as could be expected as far as the mouth of the Kolyma River, longitude 160°. But there as in eastern America the isotherm takes a sharp dip to the southward from about 69° to 52°, finally leaving Kamchatka at about 56° while the forest, here *Larix dahurica*, stretches nearly straight eastward along the upper course of the Anadyr River, coming to the sea nearly on the arctic circle at the head of the Gulf of Anadyr, more than 10° (700 miles) north of the isotherm.

The arctic vegetation zone thus defined by the forest front is a very irregular area. In the most southerly of the Aleutian Islands, which by any criterion are undoubtedly arctic in character, the boundary reaches down to latitude 51° 20′, which is a few miles further south than London. But at the mouth of the Khatanga River in the Tamir Peninsula it advances to 72° 50′, as far north as Upernivik, Greenland. This is a difference in latitude greater by about 100 miles than that from Miami, Florida to Montreal.

THE ARCTIC FOREST-FRONT NOT A CLIMATIC LINE

In an effort to harmonize temperature and tree-line various writers, Martin Vahl, Nordenskjold (1928), Brockmann-Jerosch (1919), and others have tried empirically to make up some formula that would fit the facts better than simple comparison with the isotherm. Such efforts are at best only guesses and there is little attempt to show any relation of cause and effect between the factors brought into the equations. Vahl, for example, has used the "formula[2] $v = a + bk$ where v represents the temperature of the warmest month and k that of the coldest month, and when a and b are *constants that have to be determined in each case*" i.e. are not constants at all but merely factors introduced, as a schoolboy would say, "to get the right answer." Such operations are not very helpful and may become vicious if, as sometimes happens, they impart a false appearance of mathematical precision to the statements made.

All are familiar with the fact that unexpected deviations from predictions often lead science into its most important advances. We need only recall the discovery of the two outer-most planets of our solar system by reason of the perturbations in the orbits of the others. It seems not at all unlikely that if we look behind the irregularities of the forest border instead of trying to fit them into climatic conditions, we may discover facts concerning climatic changes which will be of the first order of importance.

CLIMATIC CHANGES SUGGESTED BY ANOMALIES IN TIMBER LINE

An example of the possible fruitfulness of this point of view may be gained from consideration of the situation in northern Labrador where the forest extends 400 miles further north than apparently it should. This would suggest a recent climatic change—so recent that plant migrations have not yet adjusted the flora to the changed conditions. Now it so happens that the Danish excavations of the sites of the old Norse colonies in South Greenland exactly fit in with this inference from ecology (Hovgaard, 1925). The mediaeval Norse colonists lie buried in perpetually frozen ground. This of itself is surprising, for men do not often chop holes into ice to bury their dead. More significant, however, is the fact that the graves are grown through and through by the roots of trees. The roots even penetrated into the marrow of the bones. Now tree roots cannot grow into frozen soil. There is no question, therefore, but that within the last few hundred years South Greenland had a climate far milder than at

[2] Quoted from Nordenskjold (1928, p. 73). The italics are ours.

present, thus confirming the indication given by the forest. The graves, however, leave much to be desired as to dates and other details of the climatic change which they demonstrate. It is not at all impossible that a thorough study of timberline ecology around Ungava Bay might supply more specific information than is to be obtained from any other source.

I should add in passing that while the meteorologists accept, perforce, the evidence as to recent climatic change in Greenland they are not at all prepared to explain it.

Turning to the western side of the Continent now, the opinions of practically all explorers of Alaska are to the effect that here reverse changes are occurring and that the forest is advancing. This opinion, based on extensive but cursory observations of many men in many places, has been confirmed by detailed studies.

At Kodiak Griggs (1934) and Bowman (1934) brought out the following facts: (1) All the trees near the edge of the forest are young —less than 100 years old, whereas three miles back from the edge they exceed a meter in thickness and are over three hundred years old. (2) Many old trees now in a dense forest of younger growth are "open ground" trees with branches, now killed by overshading, clear to the base. (3) The rate of growth at the forest edge compares favorably with that of the same species, Sitka spruce, in southeastern Alaska many hundred miles behind the edge. (4) Records left by the early Russian settlers explicitly describe as treeless, areas now covered with heavy forest. (5) Peat from the bogs contains only a few scattering grains of spruce pollen such as would be blown a long distance, thus demonstrating that the present is the first forest that has occupied the ground since the beginning of the bogs i.e., since the glacial period.

Similar detailed studies, as yet unpublished, have been made by Robert Marshall around Bettles in northern Alaska, Lat. 67°, Long. 152°. These tell the same story. Here a different forest composed of white spruce is concerned. Mr Marshall tells me that the very last trees grow as fast and in every way appear as favorably situated as those many miles to the south of the forest limit and that the growth rate equals that of the same species in Eastern Canada.

PLANT RANGES SUGGESTIVE OF ACTIVE MIGRATIONS IN PROGRESS

The distribution of a number of arctic herbs, likewise, cannot be readily explained otherwise than on the hypothesis of active migration in progress. *Pedicularis capitata*, for example, is common and

characteristic of the *Empetrum* heaths of Kodiak, Lat. 58°. It is widely distributed in Asia as far as the Altai. From this region it stretches across Siberia and the American arctic through the Arctic Archipelago and enters Greenland on the northwest coast, Lat. 78°. While its abundance in the mild climate of Kodiak proves that its existence by no means requires the rigor of a polar climate, it is entirely absent from south Greenland, being restricted to the area immediately adjacent to the American arctic islands. Another wide ranging species which barely enters northwest Greenland is *Androsace septentrionalis*. In this connection it is interesting to observe that there are a dozen genera of plants which reach the Archipelago but do not cross to the milder shores of Greenland. Cases like this may not be significant however, for though migration seems altogether likely we have no knowledge of the actual fact. In almost all such cases the migration must be inferred. No actual study of the behavior of arctic species on the edges of their ranges has been made. It would be of great advantage to know about these matters instead of having to speculate. Methods of attacking such questions are available, (Griggs, 1914). Recognizing this problem, Porsild (1932), who has had more experience with arctic vegetation than any one else, remarks concerning some unsuccessful experiments of his, "I hope that the enumerated experiments with native Greenland plants will show that plant dispersals and migrations so willingly and so liberally assumed in every paper of plant geography may be quite different in nature itself."

The advancing forest is in fact almost the only case of active migration that has been worked out. Not everyone will be inclined at first to agree with me that the timberline constitutes the proper boundary of the arctic, but I believe that if anyone who doubts my thesis will try to replace the timber line by some other vegetation line, he will find himself in difficulty at once.

DIFFICULTY OF CHARACTERIZING THE ARCTIC FLORISTICALLY

The fact is that it is difficult to characterize, much less to define, the arctic by the plants that grow there. Plants confined to the arctic are surprisingly few in number. That is, there are few species, and there is not a single genus, confined to the arctic.[3] Moreover the species endemic in the arctic are not among its most characteristic plants.

[3] Of the grass genus *Pleuropogon* listed by Hooker as endemic in the arctic two species have since been discovered in west America, one in Oregon, the other in California, on the lowlands as well as in the mountains. The original species, *P. sabinei*, remains, however, one of the most characteristic of high arctic species.

Almost all arctic species, if species be taken in a broad sense, go well down into the temperate zone. Indeed, all but 150 of the 762 arctic species recognized by Hooker (1861, p. 258), "advance south of parallel 40° north."

The floristic characteristics of the arctic are chiefly negative, due to the absence from northern lands of species occurring at lower latitudes. Thus the flora of the Aleutian region includes about 350 species of seed plants and that of arctic Siberia about 400, but the arctic Archipelago has only 204 (Simmons, 1913), and many of these reach only the southern islands, while north Greenland has only about 125 species (Ostenfeld, 1926). Even so it would be easy to characterize the arctic floras if it were the important species that drop out. But the species which fail to go far north are generally those which are already scarce further south. The situation will be clear from a consideration of the plants of the extreme north where, if anywhere, definite arctic species should prevail. In extreme north Greenland, north of 83 degrees of latitude, only three flowering plants grow: The opposite-leaved saxifrage, *Saxifraga oppositifolia;* the arctic poppy, *Papaver nudicaule;* and a grass *Alopecurus alpinus.* The first two are classified by Ostenfeld as low arctic. They occur in every arctic province. Both are important members of the Katmai flora 1800 miles further south and the poppy extends to Colorado while the saxifrage reaches Vermont. Only Alopecurus can be described as high arctic and even it occurs in north Russia which barely enters the arctic vegetation zone.

On Smith Sound, several hundred miles further south but still almost 1000 miles above the arctic circle in Latitude 78°–79°, Ekblaw (1919) lists the six commonest plants as follows: the opposite-leaved saxifrage, *Saxifraga oppositifolia*, blue grass, *Poa pratensis*, arctic poppy, *Papaver nudicaule*, *Cerastium alpinum*, *Dryas integrifolia*, and *Cassiope tetragona*. It will be observed that only the two subarctic members of the extreme high arctic trio given above are here included and that our familiar Kentucky bluegrass is substituted for *Alopecurus*. Of the others, *Cerastium alpinum* is common to all arctic districts and is classed as low arctic by Ostenfeld. *Dryas integrifolia* is more limited in distribution but is also low arctic, leaving *Cassiope tetragona* as the sole type prevailingly characteristic of high arctic. But it occurs also far down into Labrador and Alaska.

Another way of approaching the problem is by considering the whole flora. Of the 125 species known from north Greenland above 76°, 11 according to Ostenfeld are subarctic, 59 low arctic, and 55

high arctic. of the species prevailingly high arctic 43 occur also in some low arctic region, Alaska, Scandinavia, Iceland, or Russia, or at low arctic stations in Greenland. Of the twelve species remaining which are confined to the high arctic, half belong to the "critical" genera *Taraxacum*, *Poa*, *Draba*, and *Potentilla*. A seventh, *Braya Thorildwulfii*, is a segregate from the widespread *B. purpurescens*. There remain *Pleuropogon sabinei*, *Deschampsia arctica*, *Ranunculus sabinei*, *Hesperis palasii*, and *Minuartia Rossii*. Only two of these twelve are even mentioned in Ekblaw's general account of the vegetation; one of the Taraxacums is mentioned merely because it is endemic and *Pleuropogon* is reported as growing "in a few of the shallow ponds." Thus the high arctic can be characterized floristically only by using species of minor importance in the vegetation. A number of high arctic species are, indeed, high arctic in one region only. The same is true in perhaps even greater degree in the low arctic.

LACK OF STRUCTURAL PECULIARITIES IN ARCTIC PLANTS

Because the plants of extreme polar habitats are all dwarfed and held close to the ground, there is a popular idea that arctic plants are possessed of some special anatomical peculiarities fitting them for the conditions in which they live. This is not the case. On this point Holm (1924, p. 81 B) speaks as follows:

> "As far as concerns the structure of arctic species it has been shown in the preceding pages that no morphological structure seems absolutely characteristic of these; they share the same development of their floral and vegetative organs with their southern allied species; they exhibit exactly the same method of vegetative reproduction as these and are in many cases not of such dwarfed stature as frequently described *******. There is thus no morphological character by which arctic and alpine species may be defined and we must therefore consider them from other points of view when the question arises to distinguish them."

ECOLOGICAL CHARACTER OF THE ARCTIC

Altogether the arctic can be characterized rather better ecologically than any other way. This is true in spite of the difficulties of arctic ecology. The prevalent vegetation type of the high arctic is open fellfield, nearly bare, rocky ground most nearly analogous to talus slopes with us. The only closed associations of any great extent are heaths dominated by *Cassiope tetragona* or by mosses, especially by *Rhacomitrium lanuginosum*, the famous "Grimmia heaths." Closed grassland is absent or restricted to very favorable situations which are best considered as oases of low arctic vegetation advanced beyond the general limit of that zone. The plants are perennial, annuals being

absent or almost so. All plants are held strictly to the ground, often rising only an inch above the general level. Bogs are formed by plants other than *Sphagnum*. Ponds are devoid of flowering plants or nearly so. This, however, is not a hard and fast rule, for while there are no aquatic flowering plants in Spitzbergen (Summerhayes and Elton, 1928, p. 265), both *Batrachium trichophyllum* and *Hippurus vulgaris* occur in north Greenland.

In the low arctic, fellfield is restricted to exposed and unfavorable situations. The heaths are dominated by *Empetrum* rather than by *Cassiope*. The most favorable habitats are occupied by grassland usually with bushes and scrub of willow, birch, or alder. The bogs may consist largely of *Sphagnum*, though that moss is of much less importance than in the boreal region to the southward.

A number of aquatics penetrate into the outer portion of the arctic zone, including, besides *Hippurus* and *Batrachium*, several species of *Potomogeton*, *Utricularia*, *Myriophyllum*, *Menyanthes*, *Callitriche*, and others.

CAUSES OF THE INDISCRIMINATE CHARACTER OF ARCTIC VEGETATION

These various considerations as to definitions, boundaries, and characterizations were no part of my original plan of study, but as I have shown it was necessary to go into them before I could undertake the problem which confronted me at the outset: Namely, the reason for the indiscriminate character of the vegetation at Katmai. Finally we are ready to undertake consideration of that problem.

The nearest analogs of tundra in temperate vegetation all belong close to the pioneer stage. The highest stages reached in the low arctic of Alaska are the poplar woods and the alder grassland. Back in the forest the poplar woods are paralleled by the cottonwood thickets that come up on new gravel bars along rivers, and something very similar to the alder grassland develops on avalanche tracks, where frequent disturbance prohibits the growth of climax forest.

A good share of the tundra is what we should call boggy, and in a country where bogs are to be found chiefly encircling and invading ponds, it is easy to see again that bogs stand close to the pioneer stage. The fellfield of the extreme north, which most nearly resembles talus slopes with us is still younger in the ecological scale. In the case of the two associations first mentioned, the river bar woodland and the avalanche track, the analogy with the arctic is rather good. If the same were true with bog and talus slope there would have been

little difficulty in working out the vegetation of Katmai. But with them the analogies are useful only insofar as they may serve in a feeble way to give one who has never seen the arctic some idea of the physical conditions of the habitats concerned. It is questionable indeed whether the attempt to draw analogies in these cases does not do more harm than good, for the differences between the arctic and the temperate types are more significant than their resemblances.

With us soggy, undrained bogs and loose, open talus slopes are so different in every way that we cannot imagine any difficulty in distinguishing them. Not so in the arctic. Neither bog nor fellfield has a distinctive flora, for most of the commonest and most characteristic of arctic plants spread promiscuously not only over bog and fellfield but over all habitats of intermediate dryness as well. And since this series, which includes the heaths, occupies the greater part of many arctic countries, herein lies the problem of arctic vegetation.

RESEMBLANCES OF ARCTIC AND RUDERAL VEGETATION

So long as I tried to solve this problem of arctic ecology by comparison with the native vegetation down here I found it impossible to proceed. Finally, however, I came to see the trouble. These northern vegetation types stand lower in the plant succession than any of the natural associations of the south. When I began to compare them with the ephemeral weed vegetation of cultivated fields a comprehension of arctic ecology began at once to dawn on me.

Go out to one of the numerous real estate developments where they have made over the landscape recently and try to classify the weeds that appear. Cataloguing the plants over several such developments, you will make a long list of familiar weeds. Now try to classify them as to habitat preference and their association with each other. You will make little progress, for the weed cover of new ground varies indefinably from place to place. The weeds, with some wellknown exceptions, have no associations. The population of any area depends much more on the kinds of seeds that happen to fall thereon than on fitness of the species present for that particular habitat.

SIMILARITY OF FELLFIELD AND PLOWLAND

One of the most evident resemblances, and perhaps one of the most significant, between fallow fields and high tundra is in the large amount of mineral soil exposed to colonization, and the further north one goes the more bare ground there is. On the fellfield the plants are spotted here and there with so much space between that a picture

of the habitat looks like a bed of shingle and the inconspicuous plants are hardly noticed except upon close inspection. This eliminates one of the most important of the ecological factors of lower latitudes. There is no struggle for room.

On the high tundra most of the plants are entirely out of touch with their neighbors. There is always plenty of free space for new plants. Thus while in the south nearly all plants have continually to wrest their living so to speak out of the very mouths of others which would take it if strong enough, in the far north the struggle for existence consists entirely of passive endurance of the rigors of the climate.

A second point of resemblance between tundra and plowland lies in the relatively small amount of humus commonly present in both. As everyone knows, one of the chief problems of agriculture is the loss of organic matter consequent upon cultivation and the ensuing wash. Fields cut out of the virgin forest soon lose the heavy coat of leaf mold which had been built up through ages of primeval conditions. Thereafter their soil approaches nearer and nearer to a mass of inorganic detritus unless organic matter is artificially added by green manures or similar means. This of itself favors the development of the species we know as weeds over the humus-loving natives originally in possession, (Croxton, 1928). These weeds both ecologically and floristically resemble arctic plants. In the arctic the formation of humus and peat either in thick layers or in small floccules is at a minimum.

Pedologists would call arctic soil very young, if they were willing to admit that the rock detritus which covers the ground in high arctic countries constitutes a soil at all. Presumably this juvenile, or better infantile, condition of the soil is due to an unfavorable climate which prevents the development of a proper soil. One would like to be able to discuss this problem in more detail but present knowledge does not permit. It is not impossible that it might have important implications.

Arctic ground is almost everywhere poor in nitrogen. This is generally attributed to the effect of low temperatures on the activity of nitrogen-fixing bacteria, but no thorough study of the matter seems to have been undertaken. The deficiency in nitrogen is so important that cliffs manured by nesting birds support a vegetation notably more luxuriant than occurs elsewhere. The arctic "barren grounds" might perhaps be "made to blossom like the rose" by the application of fertilizer.

A third and most important similarity of tundra to farmland lies

in the unstable condition of the soil. As a means of stirring up the ground and uprooting plants nothing but the plow can compare with the rigors of the arctic climate. The violence of heave and throw in daily freezing and thawing have been commented on by many writers. Another factor of importance has been brought to light by Johansen (1924, p. 26). He ascribes the bare spots on the tundra largely to disturbance by running water from melting snow and to slumping away of the ground after melting of ground ice. The plants which remain are those which happen to be favorably situated to escape such accidents. Thus tundra and field are alike in that on neither is vegetation allowed to grow for long before it is uprooted and destroyed.

If undisturbed the ruderal associations of cultivated fields and new ground soon pass into definite old field associations characteristic of the particular vegetation province concerned; white birches in New England, pines in the southern coastal plain. It is only by repeated plowing that the ruderal stage is maintained. In the north the necessary disturbance is supplied by Nature herself.

On account of the vicissitudes of freezing and thawing adjacent patches of tundra may be of very different age. While freshly denuded areas are conspicuous, as the years pass they gradually fade into the general tundra thereby introducing another element into the confusion of an explorer without detailed knowledge of the history of the areas observed.

HOMOLOGIES OF ARCTIC HEATH AND BOG

In a field the open stage wherein the soil is still largely unoccupied, which is comparable with the fellfield of the North, quickly passes into a closed "association" in which competition is keen and destructive as every gardener knows. In the extreme high arctic this open stage is permanent and succession does not go beyond the fell field.

In more favorable localities the vegetation spreads out and occupies the whole ground forming heath or bog. These are homologous with the second stage in the revegetation of a field. In the field the vegetation of this second stage may be even more erratic in composition than in the initial stage because the first pioneers consist exclusively of the species able to come up at once and they may arrive well ahead of the general weed population. In parts of the coastal plain for example, crab-grass, *Syntherisma sanguinalis*, always appears first. Following this in the second stage is a diverse assemblage made up of any one of a number of species or any mixture of them depending on the seeds that happen to be most available.

Because the ground is covered, the second stage may appear to be closed association, but this is a false appearance for such areas lack the essential character of truly closed associations in which each species present has some special fitness for the conditions of the habitat and all lacking such fitness are excluded by the intensity of the competition. If the term association as applied to vegetation means anything beyond mere physical propinquity it is clear that vegetation in this stage does not constitute proper associations at all.

This is the condition of the protean heaths and bogs at Katmai wherein the plants did not keep their places and so baffled a would-be classifier. Lack of the close-drawn competition which determines membership in associations higher in the succession explains both the apparent lack of habitat preferences in the most characteristic species, and of the infinite variation in the composition of the plant cover.

It may be needless to adduce further evidence that the tundra is in fact in the ruderal condition beyond that with which this essay is prefaced, but I shall cite one additional illustration showing how the irregularities in the distribution of arctic plants correspond with the vagaries in the occurrence of weeds. Three Greenland nunataks have been described by Warming (1888, p. 84–86). Their combined flora numbered 54 vascular plants, but no more than 27 occurred on any one of the three, and only two species were common to all three mountains. Clearly most of the 54 species, if once established, would thrive on any of these nunataks. The explanation here, as in the field, is that the flora of each is due to the accidents of immigration rather that to special fitness, and that colonization has not been completed.

The essentially unstable ecological condition of the tundra thus runs into and fits in with the instability of a higher order discussed above, namely the floristic irregularities which suggest that active migration of arctic species is still in full swing.

WEEDS NATIVE TO THE ARCTIC

I have said also that the ruderal character of arctic vegetation is floristic as well as ecologic. There is no time here to go into such an analysis of the arctic flora as would be necessary adequately to develop that fact. A brief summary with a few examples will illustrate my point.

The usual conception of arctic plants is that when they come south at all they are confined to high mountains. It will probably surprise many to learn that there are fewer species native above the arctic

circle which in their southern extensions are confined to alpine situations than of those which we know as weeds of cultivated ground. Long ago Hooker (1861, p. 277) pointed out:

> "Of the plants found north of the arctic circle very few are absolutely or almost confined to frigid latitudes (only 50 out of 762 are so); the remainder, so far as their southern distribution is concerned, may be referred to two classes; one consisting of plants widely diffused over the plains of northern Europe, Asia, and America of which there are upwards of 500; the other of plants more or less confined to the alps of these countries, and still more southern regions of which there are only about 200."

To illustrate I cite a few familiar plants of fields and other new habitats which are native to the arctic, though some of them have come to us only as introductions from northern Europe. In this connection Porsild's (1932) paper on *Alien plants and apophytes of Greenland* is most instructive.

One of the worst of our weed invaders from Europe is sheep sorrel, *Rumex acetosella*. This is native in Greenland and is abundant in the untouched natural vegetation as far north as Disco, Lat. 70°. Dr. C. O. Erlanson tells me that the Greenland plant is in all respects closely similar to our weed.[4]

Toad rush, *Juncus bufonius*, a cosmopolitan weed which with us frequents roadsides and other open places, goes far north reaching 67° 49′ in Greenland, occurring there "in places which preclude human introduction." (Porsild, 1932.)

Horsetail, *Equisetum arvense*, which though unable to compete with more rapidly reproducing annual herbs for the occupation of cultivated fields, is fundamentally similar to a weed in that it is confined to new ground and is supplanted whenever species beyond the pioneer stage can take hold. With us it is restricted to such places as sand bars and road embankments. At Katmai it dominated the ashflats for a time after the eruption, coming through ash blankets too thick for other plants to penetrate. It goes to the far north reaching Spitzbergen and the north coast of Greenland, Lat. 83°.

Chickweed, *Stellaria media*, one of the most widespread and ubiquitous of weeds occurs generally in arctic as well as temperate countries. In Greenland it enters natural vegetation uninfluenced by human occupancy, yet it is considered certainly introduced. In arctic Norway, however, it is believed primeval. (Jesson and Lind 1923, Holmboe, 1906.) Its ability to enter the native vegetation of the arctic

[4] This does not accord with Porsild's published accounts. Erlanson, however, is more familiar with the temperate plant than is Porsild.

really gives clearer testimony as to the ruderal character of that vegetation than if it were native. This is clear from a consideration of its habitats with us. Here it is strictly an ephemeral weed unable to hold on in any permanent stabilized plant cover.

Rhode Island bent grass, *Agrostis canina*, is native to the arctic Archipelago, Greenland, and arctic Europe—but not at all to Rhode Island.

Similarly, Kentucky bluegrass, which as detailed above goes to the far north, is not believed to be indigenous in the northeastern United States. H. M. Raup (1934) discovered, however, that it grows in extensive pure stands in the subarctic meadows of the Mackenzie.

Our common winter cress, *Barbarea vulgaris*, likewise is native from Lake Superior northwestward into Alaska and Arctic Europe, but comes to us here as an introduced weed.

Plantago lanceolata is given by the Canadian Arctic Expedition (Johansen, 1924, p. 41 C.) as one of the characteristic plants of the uninhabited American arctic coast. It is also in arctic Europe where, however, Norman regards it as introduced. Hereabout it is one of our worst weeds.

Ranunculus acris, one of the commonest introduced weeds in our territory, is native and abundant in Arctic Norway and in South Greenland.

Polygonum aviculare, the little smartweed which everywhere edges into well-trodden paths in this country, or a close relative (there has been a recent redefinition here) is native in arctic Scandinavia, Iceland, and Greenland as far north as 70°.

Cardamine pratensis, which in the United States is native northward, but escaped southward, is indigenous throughout Greenland up to 76° as well as in Scandinavia.

Yarrow, *Achillea millefolium* and var. *nigrescens* (Fernald 1925, p. 269), is common on the tundra of the uninhabited country of the Alaska peninsula. Whether the native Alaskan plant is the same species as ours is disputed, but our common weed is indigenous to Scandinavia and Iceland. In Greenland it is replaced by the native arctic American form.

Anthoxanthum odoratum, the sweet-smelling vernal grass which comes up in waste places everywhere hereabout, is common in Scandinavia, Iceland, and South Greenland. In the latter place, however, it is believed to have been introduced by the old Norse colonists.

Epilobium angustifolium, the fireweed whose ephemeral character in this region is attested by its common name, is one of the most

characteristic of arctic plants, occurring in all low arctic districts and ascending to 70° in Greenland.

CONCLUSION

In short every feature of arctic vegetation, the anomalies in the geographical distribution of arctic species, the occurrence of many species in all sorts of habitats, and their apparent indifference to the diverse conditions thereof, the lack of definiteness to the composition of the plant cover in any particular habitat, the physical instability of the ground itself, the general ruderal character of arctic vegetation, the large number of our weeds which are native to the arctic—all these testify to an instability in arctic vegetation very different from the relatively stable plant formations of the temperate zone.

Each of the items contributing to the belief that arctic vegetation remains in a state of flux goes to indicate that the plants of the arctic, individually and collectively, are still far from equilibrium with their environment. This conclusion has far-reaching consequences.

First, combined with the demonstrated active migration of the Alaskan forest into the arctic, it gives definite support to the supposition that vegetation there has not yet recovered from the glacial period but is still in process of active readjustment.

Second, a science of arctic ecology cannot be built up on the assumption that the place and mode of occurrence of a plant give reliable indications of its optimum habitat. As this is one of the central theses upon which the ecology of the temperate zone has been built up, it is clear that arctic ecology must be worked out on an entirely different basis.

If the study of arctic ecology be approached from a dynamic rather than from a static and merely descriptive point of view, if instead of attempting to fit arctic vegetation into a supposedly stable climate, we try to work out the great movements of vegetation that are in progress, there lies open to the investigator a rich field which bids fair to throw much light on many features of our environment and its history that have an importance far beyond the immediate problems concerned.

LITERATURE CITED

BOWMAN, PAUL W. *Pollen analysis of a Kodiak bog.* Ecology. *In press*, April. 1934.

BROCKMAN-JEROSCH, H. *Baumgrenze und Klimacharacter.* Beitr. z. Geobot. Landesaufname Pflanzengeographische Kom. der Schweiz. Naturf. Ges. vol. 6. 1919.

CROXTON, W. C. *Revegetation of Illinois coal-stripped land.* Ecology 9: 155–175. 1928.

EKBLAW, W. ELMER. *Plant life of northwest Greenland.* Nat. Hist. 19: 272–291. 1919.

FERNALD, M. L. *Persistence of plants in unglaciated areas of boreal America.* Gray Herbarium Memoirs 2. 1925.
FERNALD, M. L. *Recent discoveries in the Newfoundland flora.* Rhodora 35: 85, 120, 121. 1933.
FRIES, THORE E. C. *Bot. Untersuch. in nord. Schweden.* Upsala. 1913.
GRIGGS, ROBERT F. *On the behavior of some species on the edges of their ranges.* Bull. Torr. Bot. Club 41: 25–49. 1914.
GRIGGS, ROBERT F. *The edge of the forest in Alaska.* Ecology. *In press,* April. 1934.
HANSEN, H. M. *Vegetation of Iceland. In* Koldurp and Warming, *Bot. Iceland,* 3: pt. 1. J. Frimodt, Copenhagen. 1930.
HOLMBOE, JENS. *Stud. norske pl. hist.* Nyt Mag. 44: 61–74. 1906.
HOOKER, J. D. *Distrib. arctic plants.* Trans. Linn. Soc. 23: 251–348. 1861.
HOVGAARD, W. *The Norsemen in Greenland: Recent discoveries at Herjolfsnes.* Geogr. Rev. 15: 605–615. 1925.
JESSON, KNUD OG LIND, JENS. *Det Dansk Makurkrudts historie.* K. Dansk vid. Selsk. Copenhagen. Natur & Math. Afd. 8 R VIII. 1923.
JOHANSEN, FRITS. *General observations on vegetation.* Rept. Can. Arctic Exped., 1913–18. Vol. 5, pt. 3. 1924.
MIDDENDORF, A. VON. *Siberische Reise* 4: 1: 736. 1864.
NORDENSKJÖLD, OTTO. *The geography of the polar regions.* Am. Geogr. Soc. Sp. Pub. 8: 72, 73. 1928.
NORMAN, J. M. *Index Sup. Soc. Nat. Spec. Pl. non-vasc. Prov. arctica Norwegiae, sponte nasc.* Kgl. Norske Vidensk. Selsk. Skr. 5: 1–58. 1865.
OSTENFELD, C.H. *Bot. Faeroes.* In Warming, Bot. Faeroes 867–1026. 1908.
PORSILD, A. E. *Reindeer grazing in northwest Canada.* Canada Dept. Interior. 1929.
PORSILD, MORTEN P. *Flora of Disko Island.* Arb. Dansk. Artk. Sta. No. 11. 1920.
PORSILD, MORTEN P. *Alien Plants and apophytes in Greenland.* Med. om Grønland 92: 1–85. 1932.
RAUP. H. M. *Phytogeographic studies in the Peace and Laird River regions.* Contrib. Arnold Arbor. 6. 1934.
RIKLI, M. *Veg. Disko Island.* Vegbild. 7: 8. 1910.
SIMMONS, HERMAN G. *A survey of the phytogeography of the arctic American Archipelago.* Lunds Univ. Arsskr. nf. 9: no. 13. 1913.
SUMMERHAYES, V. S. and ELTON, C. S. *Further contributions to the ecology of Spitzbergen.* Jour. Ecol. 16: 193–268. 1928.
WARMING, E. *Om Grønlands Veg.* Med. om Grønl. 12: 84–86. 1888.

PHYSICAL GEOGRAPHY.—*Saline peat profiles of Puerto Rico.*[1]

A. P. DACHNOWSKI-STOKES and RAY C. ROBERTS, Bureau of Chemistry and Soils.

The source of organic matter found in salt and brackish waters of the sea and the question of its abundance, specific nature, and function either in relation to the nutrition of marine bacterial and animal life, to the formation of coal, oil, and petroleum, or to practical agriculture, presents a number of highly important problems. Much information has been published showing the development of swamp forests of mangrove and other halophytic plant communities, but the most significant results of vegetation at work, namely, the characteristic features of organic accumulations and the phases bearing upon past conditions, have scarcely been considered.

The opportunity for the following article arose through field work carried on in Puerto Rico in connection with a survey for the U. S.

[1] Received February 6, 1933.

Bureau of Chemistry and Soils with the cooperation of Dr. J. A. Bonnet, Chief of the Soils Division, of the Insular Experiment Station of Puerto Rico. Vertical cross sections believed to be representative of coastal swamps and salt marshes in northern and eastern parts of the island were collected by the junior author and the Station's surveyors. The former also made the determinations of soluble salts contained in the samples.[2] The descriptions of the peat profiles and the general discussion regarding them were contributed by the senior author. A specific aim has been that of basing the study upon the point of view set forth in a recent book dealing with a new system of classifying American peat deposits.[3]

Puerto Rico is an island well within the tropical zone in the Atlantic waters. It is approximately 182 km. (113 miles) long and 66 km. (41 miles) wide and includes an area of about 8,900 square kilometers (3,425 square miles). The island is largely mountainous and primarily of volcanic origin. It has been described as a portion of a chain of mountains under water, the summits of which reach an altitude of 1,350 m. (4,429 feet). Other summits of the range form the other islands which with Puerto Rico make up the group known as the Greater Antilles. A scientific survey of the region is in progress by cooperating institutions. Studies on the geology and physiography of Puerto Rico will be found in the publications issued by the New York Academy of Sciences[4] and the New York Botanical Garden.[5] A valuable descriptive account of the plant ecology of Puerto Rico and certain phytogeographic relations of the vegetation have been given by Gleason and Cook,[6] while information as to the climate and soils of the island may be obtained from the reports of the United States Weather Bureau and the Bureau of Chemistry and Soils.[7]

CHARACTERISTICS OF MANGROVE PEAT

On the coastal plain of the east side of the island are found numerous parcels of tidal mangrove swamps that grow in the water of the open bays and the open ocean where wave action is characteristic of the more exposed shores. The red mangrove (*Rhizophora mangle*

[2] The authors are indebted to Mr. E. H. Bailey of this Bureau for the hydrogen-ion determinations on the air-dried samples.

[3] Dachnowski-Stokes, A. P., and Auer, V. *American peat deposits.* In Handbuch der Moorkunde, vol. 7. Gebr. Borntraeger, Berlin. 1933.

[4] Sci. Surv. Puerto Rico I–VI. 1923–1926.

[5] Britton, N. L. and Wolcott, G. N. *Puerto Rico and the Virgin Islands.* Naturalists' guide to Americas, 700–705. 1926.

[6] Sci. Surv. Puerto Rico VII. 1927.

[7] Dorsey, C. W., Mesmer L., and Caine T. A. *Soil Survey from Arecibo to Ponce, P. R.* Field Oper. Bureau Soils, 1902: 793–839. 1903.

L.) is usually the pioneer species. This characteristic shrubby evergreen tree is widely distributed on tropical coasts and is the first to appear in the open water offshore. It extends farthest into salt water where it makes a dense growth and builds up islands of peat that are occupied by it alone. Colonies of impenetrable thickets, separated by tortuous channels of tidal salt water, push steadily seaward the margin of the swamp, gradually forming broad expanses that extend over hundreds of acres and are related chiefly to the gradient of the shore, shape of the sea floor, and the depth of salt water.

In the formation of new peat land the prominent adaptational peculiarities of the red mangrove are the specialized roots that arise from branches, grow down vertically as an interlacing tangle of stout pithy roots and together with numerous fine rootlets become anchored in the underlying soil. This dense network of roots and rootlets retards greatly the movement of sea water; it retains any decaying fallen leaves and twigs of the trees and any suspended organic matter and floating particles of silt or clay that may be carried by the water. Thus a type of peat profile is developed bringing ultimately the level of the layer to that of high tide.

Ensenada Honda type. In vertical cross section this type of profile represents one continuous layer of mangrove peat. The characteristics stated below were observed on a monolithic sample collected about 2 km. east of Ensenada Honda. It illustrates the development of a long coastal area of peat facing the waters of the ocean and connected with mangrove swamps most of which are under salt water and extend from the coast to the foothills. The morphological features of the profile may be described as follows:

Mangrove peat: 0 to 101.6 cm. brown to reddish-brown, coarse but firm fibrous peat, consisting chiefly of a porous, interlacing network of fine rootlets, yellowish-brown in color, brittle when dry, crumbling into small particles. Embedded in the tangle of rootlets are relatively small quantities of dark colored, finely divided organic sediments carried by tides and waves of sea water. A prominent feature is considerable amounts of stout roots of mangrove, the pith of which is in varying states of decomposition. The whole profile section is indistinctly differentiated, free from woody fragments and plant remains of secondary species, contains little mineral material, and is but feebly altered by soil making processes; it is the product of the roots and rootlets from a pure stand of mangrove. Soluble salts are present in the entire profile in amounts ranging between 3 and 5½ per cent and the reaction of the air-dried material is strongly acid (pH 4.3–4.6). The thickness of the layer varies in places from 1 to 1½ m. and rests abruptly on coarse white sand of unknown depth.

Many of the coastal mangrove swamps are cut for charcoal and

fuel, and serve as an important source of income. They re-establish themselves easily under natural conditions and should be used along newly built embankments as a means of preventing the wash of waves and undermining.

PEAT PROFILE FORMATION IN LAGOONS

On the north shore of Puerto Rico there are many places that are free from effective wind and wave action, but where salt water flows inland by tidal movement and produces saline conditions. The sheltered bays, estuaries, and great lagoons east of San Juan are of this nature. The shallow sea waters favor deposition of organic ooze, over and around which grows a halophytic vegetation showing transitions from saline to brackish waters and a succession of plant communities from shore lines fringed with littoral swamp forest of mangroves to marshes of cattail, rushes, and sawgrass toward the landward side. The mangrove swamps occur in strips bordering on quiet salt water in direct connection with the sea.

In general several species of mangrove compose the swamp forest. Of these the great bulk are red mangrove and to a less extent the black mangrove (*Avicennia nitida* L.). Other species such as *Laguncularia racemosa* and *Conocarpus erectus*, with an undergrowth of smaller shrubs and herbaceous plants are relatively more abundant landward. The presence of secondary species generally indicates an interference with the penetration of tidal salt water and the tendency of rains or fresh water streams to dilute periodically the salinity of the groundwater.

Along the shore at sufficient depths to preclude agitation by currents and waves, the bottom is covered with soft, black organic ooze. The formation of this residue appears to be partly a result of the action of bacteria in the salt water. By decomposing the remains of marine plants and animals a layer is formed that can be designated as sedimentary peat because of its similarity in origin and probably in chemical composition[8] to the sedimentary peat found in fresh water lakes and ponds. The thickness of the marine layer varies considerably but in some protected localities the mud-like residue is present in great abundance. Its decomposition is sufficiently slow to indicate that the constituents are altered anaerobically to a very small extent after their deposition. The various processes that might produce such beds of fine organic material, and preserve them as marine sediments,

[8] TRASK, P. D., and HAMMAR, H. E. *Some relation of the organic constituents of sediments to the formation of petroleum.* Abstract in this JOURNAL 23: 568. 1933.

have not received much consideration as yet. Some significant conclusions, however, may be drawn from the fact that the content of organic matter is consistently large and that its deposition is under saline conditions below effective wave action. For purposes of comparison the following profile is of interest.

Martin Peña type. The chief distinguishing feature of this profile is the fact that it is composed of two layers, markedly different in texture and composition. It consists typically of a surface layer of fibrous mangrove peat and an underlying layer of marine sedimentary peat. The profile was collected about 1½ km. east of Martin Peña railroad station from an area of mangrove swamp that represents an old channel-like depression and connected at one time Lake San Jose with the Harbor of San Juan. Much of the swamp forest has been cut-over for fuel; its surface is under water at sea level, and the entrance of tide water causes saline conditions some distance in the interior portion. A detailed study of the profile brings out the following:

Mangrove peat: 0 to 28 cm.; thin surface cover of black, sticky organic tidal ooze containing an occasional mollusk shell; the sediment varies in thickness from 5 mm. to 1.5 cm. Below it is reddish-brown, coarsely fibrous, matted mangrove peat which consists of a tangle of yellowish colored fine rootlets and large reddish-brown pithy aerial and lateral roots of mangrove (species of *Rhizophora* and *Avicennia*) embedded in black, finely divided organic residue. The material contains about 3 per cent of soluble salts and has a moderately acid reaction (pH 5.6).

28 to 61 cm.; finely fibered, very dark brown to mottled, more or less firm mangrove peat; it consists of a large proportion of black organic residue held in a meshwork of fine yellowish rootlets and is penetrated by a few stout, branching pithy roots in varying states of decomposition. The material is saline and acid (pH 5.1).

Sedimentary peat: 61 to 92 cm.; grayish-black, soft, oozy mixture composed chiefly of organic residue of the size of colloidal particles, together with gray colored fine rootlets. The layer is penetrated by a few pithy roots of mangrove; it becomes dense and hard when dry and breaks with smooth fractures. The content of soluble salts varies between 3 and 3½ per cent and the reaction is moderately acid (pH 5.6).

At a depth ranging from 1 to 1½ m., the underlying mineral soil is bluish green to gray plastic clay.

SALINIZATION OF A PEAT AREA

On the coastal shore of the island, between Arecibo and Barceloneta a line of consolidated sand dunes and limestone hills form a pronounced ridge. It separates from the near-by ocean an extensive level marsh nearly 13 km. long and from 1 to 1½ km. wide, known locally as Caño Tiburones. The natural outlet of the marsh is at the western end but numerous ditches and canals intended to drain it

have facilitated the entrance of salt water. Much of the surface of the marsh is at or below sea level and the natural vegetation indicates that in some places it is influenced by the denser salt water while in other parts the soil water is brackish or nearly fresh because of its slow diffusion.

Where the vegetation is still in a natural condition, Cook and Gleason[9] report that it consists of almost pure stands of cattail (*Typha angustifolia* L.) and sawgrass (*Mariscus jamaicensis* [Crantz] Britton), while at wider intervals are small patches of reed (*Phragmites communis* L.) and isolated thickets of shrubs. The vegetation changes more or less abruptly toward the western end into continuous masses of ferns (*Acrostichum aureum* L.) and still farther west into mangrove swamps where the salinity is increased by the entrance of the tides.

Ecologists are still uninformed as to the details of the origin and history of this marsh. The evidence of the surface vegetation as to the factors that operated during past periods is very slight, and there is reason to believe that the development of the marsh might be due perhaps to a progressive submergence of the coast. Since the composition and appearance of any vertical peat section depends primarily on the plant remains caused by a preponderance of species and by the successional trends of the vegetation, a detailed study of a profile should reveal any changes in natural conditions.

Caño Tiburones type. The profile described below was collected from the eastern part of the Caño Tiburones marsh, about 15 km. east of Arecibo. Its distinguishing features display two layers of peat in a reversed sequence of which the lower material is coarsely fibrous peat, developed under marsh conditions influenced by brackish water, while the upper layer is markedly dense and heavy in texture and represents conditions of nearly fresh water and a rising water level.

Sedimentary muck: 0 to 26 cm.; under cultivation; the material at the surface develops a black, granular muck, more or less mineralized; it contains bits of fine rootlets from crops (sugar cane) and shows channels of burrowing insects and worms. Downward it continues into sticky plastic sedimentary peat of heavy texture, dense, compact and hard when dry, tending to break into angular cloddy aggregates that later disintegrate into loose granules. The cultivated material is neutral in reaction (pH 7.3).

Tule peat: 26 to 58 cm.; black, stringy fibrous peat consisting mainly of soft, partly decomposed vertical stems and the rootstocks of tule (*Scirpus* sp., *Eleocharis* sp. and others), embedded in sticky plastic organic residue derived from secondary herbaceous plants. The material contains very small

[9] Cook, M. T., and Gleason, H. A. *Ecological survey of the flora of Puerto Rico.* Journ. Dept. of Agri. P. R. 12: 1–139. *Illus.* 1928.

amounts of soluble salts, is slightly acid in reaction (pH 5.9) and shows a tendency to compaction and hardening when dry.

58 to 63 cm.; band of dark gray clayey mineral material probably due to flood waters; it is mottled with black organic residue and channeled vertically with partly decomposed, flattened culms of tule sedges (*Scirpus* sp.); the material is moderately saline and acid in reaction.

63 to 90 cm.; coarse stringy-fibrous tule peat, very dark brown to black, consisting largely of vertical, partly decomposed, more or less flattened stems of tule (*Scirpus* sp.) in a matrix of plastic amorphous organic residue. No visible alterations have taken place in the material during the period of time it has been buried by the mineral sediments. The content of soluble salts is fairly high, and the reaction is strongly acid (pH 4.2).

The thickness of the layer extends to a depth of 1½ m. below the surface and the underlying mineral material is a bluish-gray, plastic clay.

It is apparent that Caño Tiburones first developed as a marsh characterized by fresh or brackish water in which tall-stemmed rushes (*Scirpus* sp.) were dominant and persisted in great abundance as the pioneer plant community. The profile section also indicates a sudden inflow of erosion water that carried with it large quantities of clayey sediments. Flooding, that may be attributed to a period of very moist climatic conditions,[10] or else subsidence, appears to have continued down to recent times. The change brought about a stand of water so nearly fresh that aquatic vegetation, forming sedimentary peat, replaced the tule marsh. The vegetation dominating at the present time is associated in places with saline conditions due to the entrance of tide water, but no particular part of it has, as yet, contributed to the development of fibrous peat.

SUMMARY

A brief discussion has been given of the more important characteristic features of three peat profiles that are representative of coastal shore conditions of Puerto Rico. These profiles from the tropics are members of a major group that includes two regional subdivisions, namely salt marshes such as exist along the open bays and estuaries of northern coastal states, and mangrove swamp forests and tidal marshes of tropical coasts and islands. To this maritime group of peat land the name halotrophic has been applied, to designate the fact that profile development is related to salt water or brackish water by the effective activity of plant communities associated in a successional trend. The peat materials are of a distinctive nature; they promise a basis for paleontological correlations and they may be significant in indicating the character of source beds of coal and

[10] *Reports of Second Conference on Cycles: Records of climatic cycles in peat deposits.* Carnegie Institution Washington, 55–64. 1929.

oil, accumulating in brackish and salt water, on or near ocean shore conditions.

PALEOBOTANY.—*A pine from the Potomac Eocene.*[1] EDWARD W. BERRY, Johns Hopkins University.

The Eocene of Maryland and Virginia comprises an older Aquia and a younger Nanjemoy formation collectively known as the Pamunkey Group, and the best general account of the geology and contained faunas is that by Clark and Martin, published in 1901.[2] Aside from undetermined and probably undeterminable drift wood in these marine beds I know of no terrestrial plants having been recorded from these deposits except the two nominal varieties of fruits described by Hollick in the volume above mentioned,[3] and referred to the form genus *Carpolithus* without any suggestions as to their probable botanical affinity. These are said to have come from the Woodstock stage, the uppermost of the two stages into which the Nanjemay formation was divided. It is these same forms in all probability which were noted by Ruffin in the last century in one of the earliest American papers on fossil plants,[4] since these objects are not of great rarity, although no one has attempted to discover their botanical affinity.

During the past summer Dr. W. Gardner Lynn of the Johns Hopkins University collected an excellently preserved cone of a new species of *Pinus* from an outcrop of the Aquia formation at Belvedere Beach on the Virginia bank of the Potomac, near the type locality of the Aquia formation. This may be appropriately named *Pinus lynni* n. sp. and described as far as the material permits as follows.

Pinus lynni n. sp.

Fig. 1

Cone thoroughly lignified and much compressed, somewhat macerated at both the apex and base. The part preserved measures 9.5 centimeters in length, 3.5 centimeters in width, and about 1.5 centimeters in thickness, so that in life it was relatively slender. That it was mature is indicated by the fact that it must have been shed or blown from the parent tree and was sufficiently dried to have been buoyant enough to have been floated into this marine basin of sedimentation. The faint impression of the seeds on the cone scales and the absence of any traces of seeds also indicates that these had already been shed. Scales triangular in profile, flat basally and somewhat thickened distad, the rhomboidal face being about 1.2 to 1.5 centimeters wide by 7 or 8 millimeters high with a prominent central transverse boss or

[1] Received Dec. 16, 1933.
[2] CLARK, W. B., and MARTIN, G. C. Md. Geol. Survey, Eocene, 1901.
[3] HOLLICK, A. Idem, p. 258, *pl. 64, figs. 11, 12.*
[4] RUFFIN, EDMUND. Amer. Journ. Sci. 9: 127–129. 1850.

Fig. 1. *Pinus lynni* Berry ×1. Eocene, Belvedere Beach, Va.

umbo crowned with a central conical point, which does not appear to have been extended, but may have been abraded before fossilization.

Among the cones of existing North American species, this Eocene form shows resemblances in the size and proportions of the cone as a whole and of the individual cone scales to the three southeastern species *Pinus taeda* Linné, *Pinus elliottii* Engelmann, and *Pinus caribaea* Morelet. I suppose that too much reliance cannot be placed on resemblances of what, after all, are superficial features, but I give them for what they may be worth. That these resemblances are really objective is indicated by the fact that if the specimen had not actually been dug out of Aqui sediments I should have regarded it of Pleistocene age in spite of the fact that the lignification is more advanced than is usual in material of Pleistocene age.

Although *Pinus* is a reasonably ancient geological type and characteristic cones are found in this region in the late Lower Cretaceous (Patapsco formation) as well as in corresponding horizons in Europe, none have been encountered in the middle Atlantic states in the long interval between the Upper Cretaceous and the Pleistocene.

Pinus is, of course, present in western North America and on the other north temperate continents during the Eocene, Oligocene and Miocene, but is usually represented by woods or impressions of the foliage and actual cones are relatively rare.

Comparisons with described fossil cones afford nothing of pertinent interest. I assume, from the character of the cone scales and the resemblance to the existing species mentioned above that the present fossil belongs in the Pitch pine section of the genus.

The present occurrence is of great interest as it gives a hint at least of the character of the vegetation which clothed the shores of this region in early Eocene time, its essentially temperate character and the contrast which it suggests between this region and that of the shores of the Mississippi Gulf embayment where the very extensive known flora contained so many immigrants from more southern latitudes.[5]

[5] Berry, E. W. U. S. Geol. Survey Prof. Paper 156. 1930.

PALEOBOTANY.—*Pliocene in the Cuenca Basin of Ecuador.*[1] EDWARD W. BERRY, Johns Hopkins University.

In 1932 Dr. George Sheppard of Guayaquil, Ecuador, transmitted to the U. S. National Museum, a small collection of freshwater invertebrates from two localities near the towns of Biblian and Paccha in the Cuenca Basin of southern Ecuador.

This was described by Marshall and Bowles[2] who enumerated 3 gastropods and 2 lamellibranchs—all new, which suggested comparisons with the so-called Pebas molluscan fauna from eastern Peru[3] of probably Pliocene age.

Recently I received from Dr. Roy E. Dickerson, Chief Geologist of the Atlantic Refining Company, two small collections which he made in the Cuenca Basin of Ecuador in 1927. These, although small, are of considerable interest. The first of these comes from an outcrop on the road from Biblian to Cuenca in the Azogues valley, where there is a good exposure of what Wolf many years ago noticed and referred to as "Arsenisca de Azogues."[4] The exact locality is along the Biblian-Cuenca road on the right side of the Rio Azogues, 16 kilometers south of the town of Biblian and 3 or 4 kilometers above the juncture of the southerly flowing Rio Azogues with the northerly flowing Rio Gualuabamba to form the easterly flowing Rio Paute.

The second locality is 3.1 kilometers southeast of Biblian in the Azogues valley and on the left side of the valley. The material from the latter locality is a compact, somewhat bituminous, neutral gray (K in Goldman and Merwin's color chart for sediments) shale which has the appearance of being a devitrified volcanic ash. No tests have been made to determine whether or not it is a true bentonite. I have not found any certainly determined plant fragments in this shale, but it does contain numerous cyprinodont fish scales, one of which is figured in the present paper. One of these is shown in Fig. 1 and is seen to be nearly circular with concentric growth lines and the usual longitudinal grooves on the anterior half. It is typically cycloid and may represent the same species of fish as that described by White (see infra) from the Loja Basin.

The material from the southernmost locality, first mentioned above is of two sorts—a whitish or light gray paper shale with plant remains

[1] Received Dec. 16, 1933.

[2] MARSHALL, W. B., and BOWLES, E. O. *New freshwater Mollusks from Ecuador.* U. S. Natl. Mus. Proc. **82**: art. 5. 1932.

[3] For a summary of the literature on Pebas see GARDNER, J. A. THIS JOURNAL **17**: 505–509. 1927.

[4] WOLF, T. *Viajes cientificos por la Republica del Ecuador-Relacion de un viaje geognostico por la Provincia del Azuay*, pp. 55–56. 1879.

and a slightly darker and more silty material with molluscan remains, which latter have caused more or less calcareous cementation.

The molluscan remains comprise a single specimen, doubtfully identified with *Potamolithoides biblianus* Marshall,[5] and a large number of specimens of a freshwater gastropod, which Mr. Marshall

Fig. 1. Cyprinodont fish scale.
Fig. 2. Leaflet of *Macrolobium tenuifolium* Englehardt.

states (letter of November 25, 1933) represents a new genus resembling *Gyrotonia* and other Streptomatidae of the southern United States. The paper shales contain fish-scales like those from the previous locality and many fragmentary impressions of plants. Only one of these is sufficiently complete to permit of identification and this proves to be a leaflet of *Macrolobium tenuifolium* Engelhardt[6] described originally from Loja, Ecuador. This specimen is shown in Fig. 2. In this connection it is pertinent to call attention to the small cyprinodont fish described by White[7] from the Loja deposits as *Carrionellus diumortinus* gen. et sp. nov. The present scales are somewhat larger than White had, but he mentions one specimen which indicated a fish twice the size of his complete specimens.

I discussed the Loja flora in 1925 and concluded that it represented a late Tertiary, and very probably a Pliocene assemblage, preserved in water laid sediments, largely volcanic ashes and at a lower altitude than that at which its existing representatives are now found.[8] More

[5] MARSHALL and BOWLES. Op. cit. p. 4, *pl. 1, figs. 1–3*.
[6] ENGELHARDT, H. Abb. Senck. Naturf. Gesell., Bd. 19: 20, *pl. 2, fig. 17*. 1895.
[7] WHITE, E. I. Ann. Mag. Nat. Hist. ser. 9, 20: 519–522. 1927.
[8] BERRY, E. W. Johns Hopkins University Studies in Geology No. 10: 79–136, *2 figs., 6 pls.* 1929.

recently through the kind cooperation of Professor Clodoveo Carrion of Loja I have received material from a total of 18 localities in the Loja Basin scattered from the nudo of Cajanuma at the southern end to a locality 6 kilometers north of Loja.

Similar late Tertiary deposits have a considerable areal extent in the tributary valleys of the Rio Catamayo east and south of the town of Malacatos which is 27 kilometers south of the town of Loja. Engelhardt, in the paper already cited, recorded similar plant-bearing material from Tablayacu in the valley of the Rio Jubones, north of the nudo of Acayana.

The present occurrences in the Cuenca Basin demonstrate the presence of similar continental deposits a considerable distance farther north than was hitherto known, so that now we have actual records of the presence of such deposits over a distance of at least 170 kilometers from Biblian on the north to Malacatos on the south. Whether all these represent the reworked remnants of a single great volcanic eruption in Pliocene times and whether the resulting sediments once formed a continuous deposit is not known. Some of the deposits in the Loja basin are horizontal and in any event were formerly more extensive than they are now. All are undoubtedly of approximately the same age. The fossil plants in the Loja basin occur at altitudes between 7000 and 7300 ft., those in the Cuenca basin at an altitude of about 8000 ft. Both are now in the temperate altitudinal zone, whereas the fossil plants are mostly meosphytic types of the tropics and indicate not only a much lower altitude at the time they were living, but also a better distributed rainfall than that of the present in the Cuenca and Loja basins.

In considering the correlation of these inter-Andean deposits with those of Pebas in eastern Peru, attention should be called to the Pliocene fossil plants which have been described from the Rio Aguaytia in eastern Peru from beds which are probably a part of the same formation as those containing the so-called Pebas molluscan fuana, since apparently malacologists never read geological or paleobotanical papers. This small but exceedingly interesting flora[9] seems clearly to be of Pliocene age and contains several species which are also present in the Loja Basin.

[9] BERRY, E. W. Johns Hopkins University Studies in Geology No. 6: 163–182, *pls. 1, 2.* 1925.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held on January 16, 1934, elected the following officers for the ensuing year: *President*, MATTHEW W. STIRLING; *Vice-president*, FRANK H. H. ROBERTS, JR.; *Secretary*, FRANK M. SETZLER; *Treasurer*, HENRY B. COLLINS, JR.; *Vice-President of the Washington Academy of Sciences*, MATTHEW W. STIRLING; *Members of the Board of Managers*, BIREN BONNERJEA, GEORGE S. DUNCAN, HERBERT W. KRIEGER, WILLIAM DUNCAN STRONG.

The following is a report of the membership and activities of the Society since the annual meeting held on January 17, 1933.

Membership:	
Life members	3
Active members	46
Associate members	6
Honorary members	22
Corresponding members	22
Total	99
Deceased:	
Active members	1
Honorary members	1
Total	2
Resigned:	
Active members	3
Associate members	3
Total	6
New Members: Active	2

The Society lost through death the following members: *Honorary:* Prof. W. H. HOLMES, one of the founders of the Society and a past president; *active:* Captain ROBERT R. BENNETT.

Members elected during the year were: Mrs. MARGARET WELPLEY and the Honorable Dr. PEDRO M. ARCAYA, Minister of Venezuela.

The financial statement (Treasurer's report) is as follows:

Funds invested in Perpetual Building Ass'n		$1114.06
21 shares Washington Sanitary Improvement Co., par value $10 per share		210.00
2 shares Washington Sanitary Housing Co., par value $100 per share		200.00
Cash in bank		246.04
Total		$1770.10
Bills outstanding:		
To American Anthropological Ass'n	$60.00	
To printer	3.75	
Total	$63.75	63.75
Net Balance		$1706.35

Papers presented before regular meetings of the Society were as follows:

January 17, 1933, 643rd regular meeting, *The probable route of DeSoto through the Southeastern States*, by Dr. JOHN R. SWANTON, ethnologist, Bureau of American Ethnology.

February 21, 1933, 644th regular meeting, *Folk-lore in some languages of northern India*, by Dr. BIREN BONNERJEA of the Foreign Mission School, Catholic University.

March 21, 1933, 645th regular meeting, *Daily life of the James Bay Cree*, by Dr. JOHN M. COOPER, Catholic University of America.

April 18, 1933, 646th regular meeting, *The cultures of Stone Age Man in the Old World*, by L. LORNE WEDLOCK.

October 17, 1933, 647th regular meeting, *Notes on southeastern aboriginal history*, by Dr. JOHN R. SWANTON, ethnologist, Bureau of American Ethnology.

November 21, 1933, 648th regular meeting, *Religion of the eastern Cree*, by Dr. JOHN M. COOPER, Catholic University of America.

The regular December meeting was cancelled by the Board of Managers.

All regular meetings were held in room 43 of the new National Museum.

FRANK H. H. ROBERTS J.R *Secretary.*

GEOLOGICAL SOCIETY

506TH MEETING

The 506th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Oct. 25, 1933, President C. N. FENNER presiding.

Informal communication.—W. H. BRADLEY presented graphs showing the existence of a 10 year cycle in the growth rings of silicified coniferous wood from the upper part of the Green River formation (Eocene) of Wyoming. It seems probable that this cyclic growth is to be correlated with the cycle of sun spot numbers though it may well have been modified by other factors.

Discussed by Mr. F. E. MATTHES.

Program: CHAS. B. HUNT: *Tertiary structural history of parts of northwestern New Mexico.*—The structural deformation of the southern San Juan Basin, New Mexico, is closely related to important nearby uplifts. These uplifts are: The Zuni Mountains, an asymmetric anticline with steep west flank; Mesa Lucero, a broad gentle dome abruptly faulted down on the east side; Sandia Mountain, a block mountain, tilted east and downfaulted on the west; and the Nacimiento Range, an asymmetric anticline with local reverse faulting along the steep west flank.

Several groups of rocks in the region contribute to determining the sequence and age of the deformation. The earliest are Cretaceous sedimentary formations which comprise most of the surface rocks. The porphyritic lavas erupted by the Mount Taylor volcano overlie the northward tilted and folded Cretaceous, and were followed slightly later by sheet basalts erupted on erosion surfaces around Mount Taylor. The fluviatile Santa Fe formation of this region was apparently deposited in the topographic depression that resulted from the down faulting of the graben between Mesa Lucero and Sandia Mountain. The deepest part of the depression was probably near the present Rio Grande, and successively younger beds overlapped the sides of the subsiding trough. Random collections of vertebrate fossils indicate late Miocene and Pliocene age, but the Santa Fe locally overlaps erosion surfaces only 100 feet above arroyo bottoms and only 50 feet above flood plains in which the arroyos are incised. Accordingly, some of the youngest Santa Fe beds may be younger than Pliocene. The sheet basalts around Mount Tay-

lor seem to be about the same age as the lower part of the Santa Fe, and the Mount Taylor eruptions are therefore probably middle or late Miocene.

The deposition of the Santa Fe followed all except the very latest block faulting in the graben. The faulting had therefore mostly taken place before late Miocene but continued into the Pliocene. The northward tilting and associated folding of the southern San Juan Basin involved the early Eocene Wasatch formation but had occurred before the eruptions of Mount Taylor. The deformation was produced by the uplifts of the Zuni and Lucero regions which can, therefore, be limited as post-early Eocene and pre-late Miocene. There is stratigraphic evidence that Sandia Mountain was formed contemporaneously with the graben faulting. The Santa Fe is involved in the latest movements at the north base of the mountain the same as farther east.

The Nacimiento uplift is post-early Eocene for the Wasatch is turned up steeply along the west flank. The presence along the range of undisturbed erosion surfaces at roughly the same elevation above present drainage as the basalt-covered surfaces around Mount Taylor indicates that the Nacimiento Range is pre-basalt in age. Renick has reported that the Santa Fe is involved in the Nacimiento uplift. There is a transition zone a few miles wide at the south tip of the uplift and north edge of the graben, and late movements of block faulting in this transition zone involve the Santa Fe as they do farther south in the graben. But so far as now known the Santa Fe is not involved in the uplifting. The fact that the Santa Fe locally rests on only slightly disturbed erosion surfaces sloping from the Nacimiento is confirmatory evidence that the uplift is pre-Santa Fe. Its date therefore is probably post-early Eocene and pre-late Miocene. (*Author's abstract.*)

Discussed by Messrs. SEARS, G. R. MANSFIELD, TRASK, RUBEY, and C. S. ROSS.

C. P. ROSS and CHARLES MILTON: *Stratigraphic correlation by heavy minerals in Paleozoic beds in Idaho.*—In order to assist in the stratigraphic correlation of the different Paleozoic formations in the Bay Horse region, Idaho, a study was made of the heavy mineral content of 46 specimens from this and neighboring areas. The specimens were not collected with this purpose in mind and a number were unsuited to it. All the rocks studied were thoroughly cemented, largely recrystallized and metamorphosed to a greater or less extent. Some had undergone intense contact metamorphism. Many contained abundant flaky carbonaceous and argillaceous material. In spite of these disadvantages the results are sufficiently distinctive and consistent to have suggestive value in correlation. The principal question was as to the correlation of certain contact metamorphosed beds in the western part of the Bayhorse region. Eliminating from consideration minerals of probable syngenetic origin, the detrital heavy minerals in these beds accord closely with those in beds of known Carboniferous age in the Hailey quadrangle and are quite different from the assemblages of detrital heavy minerals found in any of the older rocks studied. This fact accords with other evidence and the conclusion is regarded with confidence. Other distinctions can be made on the basis of differences in the assemblages obtained from different rocks but these are somewhat less positive.

In general, the results of the study indicate that even in sedimentary rocks poorly adapted to it by reason of induration and metamorphism the investigation of the content of detrital heavy minerals may yield information of value. (*Authors' abstract.*)

Discussed by Messrs. FENNER and FERGUSON.

EUGENE CALLAGHAN: *Some aspects of the geology of the Cascade Range in Oregon.*—The results of field work in the Cascade Range south of Mount Hood during two seasons—one of which was under the direction of Prof. A. F. Buddington—as well as the data published by other workers, permit a few generalizations concerning some of the geological features of this large region of volcanic rocks. In a certain sense the Cascade Range is the dissected western margin of the large plateau-like area of dominantly volcanic rocks in the northwestern part of the United States. This is particularly true of the range in California and in the southernmost part of Oregon, but farther north topographic features, distribution of rock types, and linear elements appear which distinguish the Cascade Range from adjacent physical divisions.

For the geologic description it is convenient to divide the range south of Mount Hood into two parts, to which the terms Western Cascades and High Cascades are applied. This is largely on the basis of a pronounced unconformity in the stratigraphic sequence of lavas and consequent topographic differences. The High Cascades is the easternmost belt and is characterized by rolling upland, partly or wholly preserved volcanic surfaces, and volcanic cones in various states of preservation. The Western Cascades is characterized by deep dissection, lack of preserved uplands, and long ridges sloping toward the major drainage lines.

The rocks of the High Cascades are greatly varied, but the western margin of the area is composed chiefly of olivine basalt which extends in long tongues down valleys in the Western Cascades. The large cones appear to consist chiefly of hypersthene andesite. The lower limit of age of the rocks of the High Cascades is not known, but they are believed to be largely of Pliocene and Pleistocene age. They have not been deformed appreciably.

The older rocks of the Western Cascades are divided into two groups on the basis of dominant rock type and associated structural features. One group is characterized by black glass-bearing lavas which are chiefly andesites but contain some basalt. These occur in two areas along the western margin of the Western Cascades—one in the Rogue River Valley area and the other along the east side of the Willamette Valley. In most places these rocks dip to the east or northeast. Those in the Rogue River area range in age from Eocene to middle Miocene. The second group occupies the remainder of the Western Cascades and is characterized by labradorite andesite, but contains many other varieties. Because these flows are heterogeneous, deformation structures cannot be readily ascertained but both warping and faulting have been noted. These rocks are younger than most of the black lavas but are believed to be largely of Miocene age.

Linear elements of the Cascades include the elongate outline of the range as a whole; a line of quicksilver deposits on the western margin between Black Butte and Rogue River; a line of complex sulphide mineral deposits which coincide for the greater part of its length with a line of stocks, dikes, and plugs of porphyritic diorite and granodiorite extending almost through the center of the Western Cascades; and the belt of volcanic cones in various states of preservation extending throughout the High Cascades.

The ten mineralized areas have a recorded production of approximately $1,000,000, almost entirely in gold from the oxidized portions of sulphide veins. In the unoxidized condition these veins are characterized by sphalerite, galena, chalcopyrite, and pyrite. Tetrahedrite, bournonite, and arsenopyrite occur in some veins. Quartz is the chief gangue mineral, but many

others occur—including johannsenite, a new manganese mineral described by Mr. Schaller. Some evidence of areal zoning of mineralization was found. (*Author's abstract.*)

507TH MEETING

The 507th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Nov. 8, 1933, President C. N. FENNER presiding.

Informal communications.—PARKER TRASK reported on two publications of the results of the German Atlantic Expedition of the Meteor in 1925 to 1927. The expedition studied all features of the Atlantic Ocean between latitudes 20° N. to 60° S. The publications of the Expedition are expected to provide the greatest advance in oceanography since the Challenger Expedition. One of the reports by H. Wattenberg is a comprehensive treatise on the calcium carbonate and carbon dioxide content of the sea water. It contains many tables relating to the factors influencing the solubilities of these substances in the sea water. Maps are presented to show that the saturation of the surface water with calcium carbonate increases from 100 per cent in the southern part of the South Atlantic to 150 per cent at the equator. The water below a depth of 100 fathoms is reported to be between 90 and 100 per cent saturated with calcium carbonate. The influence of boron is ignored in the computation of these figures. If they are corrected for boron, they become about 50 per cent greater for surface water, but not much greater for subsurface water which has a lower pH. The second report by Wüst discusses the circulation of the bottom water. It contains many tables and maps among which is one emphasizing the northward drift of Antarctic water at the bottom of the Atlantic.

Discussed by Mr. BRADLEY.

A. R. BARWICK exhibited a specimen of *Cuculea gigantea* from the lower Eocene Aquia formation collected at Fort Washington which contained a pearl-like growth.

Program: CHARLES B. READ and ROLAND W. BROWN: *Genus* Tempskya *in western North America.*—The fossil ferns called *Tempskya* differ from the common modern ferns in having a trunk known as a "false stem." Externally these fossils have the appearance of petrified palm trunks, but transverse sections of well-preserved specimens reveal their true fern nature. Such sections usually show a number of horseshoe-shaped stems embedded in a mass of roots, the latter being fairly uniform in size, circular in cross-section, and smaller than the stems.

The first American *Tempskya* came from the Patapsco formation of Maryland and was called *Tempskya whitei* by Berry in 1911. In 1924, A. C. Seward described a fine specimen collected from sediments of Colorado age in Montana and called it *Tempskya knowltoni.* During the past few years field work in southeastern Idaho, west-central Wyoming, and eastern Utah has resulted in the collection of much new material which it has been the privilege of the authors to study. Although the authors are not ready to publish the details of this study, enough information has been accumulated to show that these collections contain at least two new species of *Tempskya.* Anatomical details throw new light on the habits and affinities of the genus. It is becoming apparent that these *Tempskyas* may be very helpful in the stratigraphic correlation of the Cretaceous deposits containing them. (*Authors' abstract.*)

Discussed by Messrs. BUTTS, G. R. MANSFIELD, MISER, and GRIGGS.

J. C. REED: *Gravel-filled basins in the Nez Perce National Forest, Idaho.*—The Nez Perce Forest of north central Idaho embraces an area in the Clear-

water Mountains in which are at least half a dozen small basins that contain auriferous gravel. Three of these, those of Elk, Newsome, and Meadow Creeks have been examined in some detail. The basins studied range in length from about 5 to about 10 miles and are about 3 miles wide. Each is surrounded by a bed-rock divide broken only by the narrow, V-shaped canyon of the stream that drains it. Where the basins have not been trenched during the present erosion cycle, the quiet, meandering streams wandering through them are entirely out of harmony with their actively eroding portions farther downstream. The sediments in the basins probably once covered a considerably greater area than at present as is indicated by isolated patches of gravel on certain interstream divides.

The size and shape of the basins, and their location in a region where the bed rocks offer about the same resistance to erosion, appear to rule out the possibility that they were excavated by simple erosion at the heads of certain streams, whereas farther down their courses, the same streams flowing over the same kinds of rocks cut narrow gorges. But, the basins do appear to be at least in part erosional because the floors of the basins extend as benches well up into the basins' tributary valleys except those which enter from the west sides.

The western sides of the basins are straighter and steeper than the others and in one placer pit, along the western edge of Elk Creek basin, Lindgren actually observed a vertical fault separating unconsolidated sediments and gneiss. Large blocks of Columbia lava, more than a square mile in area, have been let down approximately 1000 feet along a fault that still forms a well-defined scarp that bounds Meadow Creek basin on the west. The basins appear to be gravel-covered portions of a pediment-like erosion surface cut off from their normal outlets by structural movements. This pediment-like surface was formed below an older somewhat deformed erosion surface that in this vicinity ranges in altitude between 4500 and 8000 feet above sea level. (*Author's abstract.*)

Discussed by Messrs. ALDEN and BRADLEY.

H. M. EAKIN: *An accidental large scale model of diastrophic action.*—Levee building across old clay-filled basins of cutoff lakes in the Mississippi Valley is frequently complicated by shear failure of the foundation, persistent subsidence of embankment materials, and extensive displacement and deformation of clay formations adjacent to the growing levee. In 1931 one of these failures at Ward Lake, near Sherard, Mississippi, was studied in detail throughout the period of instability.

Immediately following initial failure of the foundation, profiles were run daily over some 25 ranges at right angles with the levee line and corresponding with the standard 100-foot stations of the location survey. After the first few days weekly surveys were substituted and these continued until the levee finally became stable and was topped out.

In addition to recording topographic changes, about 140 borings were made on three selected ranges to determine final underground distribution of fill material. Also, observations were made covering phenomena of expansion and compression; of elevation and subsidence, and horizontal migration of surface areas, of folding, faulting and mass deformation of the surface stratum and of upward migration of clay and local emergence of clays and water at the surface. The old lake bed at this place is about half a mile across. The original clays are 15 to more than 75 feet deep, and overlie gritty sands and gravels. The surface clays are oxidized and somewhat toughened down

to lowest water level, some 10 feet below the surface. Below this the deeper clays are wet, blue, and soft, containing about 45 per cent by weight of water.

The first re-adjustment was a general sinking of the faulted-off portion of the fill from a few inches to about 10 feet on the various ranges, and compensatory uplift along the toe line of the new fill. These movements together comprised a rotation of an elongated body of fill material and underlying clay. At the ends of this prism transverse faults appeared, with opposite differential displacements on the two sides of a relatively undisturbed axis of rotation.

Filling operations from this time onward concentrated on dumping material across the fault line onto the subsiding limb of this rotating prism. The rotation persisted in this zone throughout subsequent operations. Measurement of subsidence was carried on by crow-foot method until it had amounted to 96 feet and was then discontinued. Total subsidence along the fault line must have been several hundred feet.

Along the line of initial uplift at the outer margin of the zone of rotation there appeared, as operations continued, a system of vertical block faults. The blocks tended at first to spread slightly apart, then all tilted their tops back toward the levee so that each rested inclined upon its neighbor. The zone as a whole continued to show tension and spreading. Eventually clays were faulted upward along certain lines among the blocks and both clays and water appeared at the surface along these lines.

The next distinctive zone outward from the levee bordering on the zone of initial uplift and subsequent spread and clay extrusion was that of the outward limb of the initial uplift feature. This limb moved outward and slightly upward without notable deformation. It is apparently a neutral zone of deformative forces, giving a zone of structural integrity. However, this zone represented a maximum of horizontal movement and a minimum ratio of vertical to horizontal displacement. This ratio was about 1 to 10, elevation amounting to 25 feet against horizontal movement of about 250 feet.

Next outside the zone of structural integrity there developed a zone of compression, manifest at first in simple flexures of the crust that gradually became overturned folds and thrust faults. Both overthrusts and underthrusts developed, but overthrusting was predominant. Several grabens developed in which a sinking strip of land was overridden from both sides and finally buried completely. This zone of compression widened by development of new flexures at its outer margin. Each flexure went through about the same history of overturning, faulting, over riding to a position of stability on the succeeding block and then moving outward with the latter in about the same relative position.

Outward beyond the last flexure of the zone of compression was a final zone of disturbance, characterized by simple uplift receding from a maximum of 2 to 4 feet at the toe of the flexure to zero out 150 to 200 feet beyond.

Beneath the tilting blocks and emergent masses of clay in the zone of tension and beneath the deformed surface member in the zone of compression the clays penetrated by borings showed a lack of original structure and cohesion, clearly due to flowage. In the zone of compression this condition was characteristic of the clays from about 10 to 20 feet below the surface. At the margin of the zone of rotation this condition was found under fill at various depths, down to about 55 feet.

It is plain that the general phenomenon is energized by the head of new fill placed in the embankment. This is supportable up to a certain intensity by cohesion and friction in the underlying and adjacent clays, part of the load being transmitted to adjacent lands by the structural strength of the upper member of the clays. Shearing stress is thus at zero under the central part of the fill and at maxima near its margins. The development of actual shear at one or the other of the margins of new fill results in rotational subsidence and displacement of underlying clay. Subsurface currents in the clay are the obvious explanation of the rotation of the fault blocks in the zone of initial uplift and tension; the dragging of strips of land over and under each other in the zone of compression and the elevation of the land surface in the outer zone of simple uplift.

The horizontal extent of subsurface flowage naturally has exceeded surface movements in all situations. Where surface migration has amounted to 250 feet, the increment in cross-section area of lands of the outward zones indicates at least 250 feet additional movement of the underflowing sheet of clay.

The phenomena of the Ward Lake occurrence are generally characteristic of similar occurrences at many other old lake sites in the Valley. This orderliness suggests that the general phenomenon is controlled by definite and perhaps broadly applicable mechanical laws. If these laws are sufficiently general to apply to diastrophic action on a continental scale it would appear that we should be able to identify in the geologic structures of our mountain systems the same general zones of differential forces and movements, namely: 1. A zone of subsidence, perhaps manifest as an off shore deep, or inland graben generally parallel with the shore line or mountain axis. 2. A zone of moderate uplift, expansion, intrusion and extrusion; 3. A zone of moderate deformation and absence of extensive igneous members; 4. A zone of compressional folding and faulting with marked overthrusting, underthrusting and local grabens, diminishing to overturned folds and finally to simple step folds; 5. A plateau region of simple structure, falling off in elevation approximately with the dip of the youngest beds to finally merge with an undisturbed plain. (*Author's abstract.*)

Discussed by Messrs. C. W. WRIGHT, COOKE, G. R. MANSFIELD, J. C. REED, RUBEY, ALDEN, HENDRICKS, BARWICK, BUTTS, BROWN, TRASK, BRADLEY, and HEWETT.

508TH MEETING

The 508th meeting of the Society was held at the Cosmos Club November 22, 1933, President C. N. FENNER presiding.

Program: C. H. DANE and W. G. PIERCE: *Fossil sink-holes in Cretaceous beds of Prowers County, Colorado.*—In a small area in sec. 6, T. 22 S., R. 44 W., Prowers County, Colorado, the exposed Upper Cretaceous rocks record the former presence of three sink-holes, between 100 and 200 feet in diameter and from 150 to 250 feet apart. Collapsed and brecciated masses of the Smoky Hill marl member of the Niobrara formation occur in the central parts of two of the subsidence areas and collapsed masses of the Hays limestone member of the Niobrara occur in all three. These collapsed masses are in contact with the upper part of the Carlile shale, which normally underlies the Niobrara formation, and is about 200 feet thick. Some of the collapsed filling has thus dropped 65 feet,—the thickness of the Hays limestone. A normal fault which may have preceded or accompanied the subsidences extends northward between them. It has a downthrow of perhaps 20 feet to the west.

The sink-holes are attributed to removal of soluble material from the Greenhorn limestone, which underlies the Carlile shale, or possibly to removal of soluble salt and gypsum from Permian rocks at greater depths, with subsequent natural stoping upward through the overlying rocks. The solution may have been first localized and aided by downward water circulation along the small fault.

The time of collapse can not be closely dated. It took place before the immediately superjacent topography was developed, for the Smoky Hill marl does not now crop out within two miles of the sink-holes, from which it has evidently been stripped back by erosion. The collapse probably occurred at some time after the irregular folding and faulting that has in places in western Kansas and eastern Colorado deformed the Tertiary sediments which form the surface of most of the High Plains. This deformation should locally, in faulted areas, have allowed downward percolation of ground water to soluble horizons. (*Authors' abstract.*)

Discussed by Messrs. RICE, MISER, THOMPSON, TURNER, MCKNIGHT, JOHNSTON, and MEINZER.

PHILIP B. KING: *The Cretaceous of West Texas.*—Mesozoic deposition began in trans-Pecos Texas in a geosyncline whose trend cut across that of older Paleozoic structural lines. In this area, which lies in the western part of trans-Pecos Texas, a great thickness of sandstone and finer clastic sediments was laid down in late Jurassic and early Cretaceous time. This was followed by the deposition of a great mass of limestone in the geosyncline, but to the northeast the beds of equivalent age are thinner, and change first to a neritic marly facies, and then to a sandy marginal facies that overlapped the Paleozoic rocks. The form and dimensions of the limestone mass are comparable to the early Paleozoic limestones of the southern Applachian geosyncline. The limestones are followed by Upper Cretaceous marine shaly beds which pass upward, east of the Jurassic and Lower Cretaceous geosynclinal area, into continental beds with an increasing amount of volcanic material toward the top. That the volcanic material is indicative of the beginning of a period of diastrophism is suggested by its association with conglomerates which contain fragments of the older rocks. The center of activity must have been to the west, however, for the well rounded pebbles have probably traveled a great distance from their source. Finally, the diastrophic movement culminated at the end of Cretaceous deposition, and the rocks northeast of the geosyncline were broadly folded and deeply eroded. In early Tertiary time, lavas were spread widely over the eroded rocks east of the geosyncline, and in places also overlapped the strongly folded rocks of the geosynclinal area. (*Author's abstract.*)

Discussed by Messrs. SEARS, HESS, and STEPHENSON.

F. E. MATTHES: *Wind-faceted pebbles from the glacial drift of Nantucket.*—A series of pebbles was exhibited showing successive stages in the production of faceted forms by sand blast action—beginning with a pebble having one incipient facet, and leading up to typical "dreikanters" and other multifaceted forms. Criteria were presented for distinguishing wind-cut facets from stream-cut, glacial, and joint facets. The distinctive feature of all wind-cut facets is the sharp, clean cut terminal edge at the leeward border. The windward border is commonly rounded, often grooved. Facets cut on convexly curved pebbles tend to become nearly plane, sometimes slightly concave. On multifaceted pebbles that have had a long and varied eolian history nearly all the facets may be bounded by sharp edges in consequence of the progressive encroachment of new facets on old ones.

Stream-cut and glacial facets seldom have sharp, clean edges, as the fluvial and glacial processes work rudely, each in its own way. Joint facets as a rule have sharp edges, but these are in detail ragged and splintery. Their surfaces, though approximately plane, likewise are in detail rough and broken by minute scarps, scales, and other irregularities.

High polish is not an invariable characteristic of wind-faceted pebbles. Many of the most beautifully faceted pebbles on Nantucket, although well preserved, have a dull, mat finish. This is due, probably, to their having been cut by coarse sand driven by violent gales. A finer abrasive, actuated by moderate winds, would doubtless have given them a more perfect, gleaming polish.

Wind-faceted pebbles have been found in the glacial deposits of Nantucket, Martha's Vineyard, and neighboring portions of the main land by several observers, notably by Shaler, Gulliver, W. M. Davis, Woodworth, and Bryan, yet there is still uncertainty as to the time when the sand blast action prevailed. Wind-cut pebbles abound in the hummocky kame moraine that covers a large part of Nantucket, but that deposit, having been much disturbed by the overriding ice, affords no satisfactory clew to the period of eolian activity. Much clearer is the evidence presented by the Squam Head bluff. It shows the wind-cut pebbles in place, in thin layers of gravel associated with beds of compact sand that are gently flexed and only locally contorted. These beds, 30 feet in aggregate thickness, are believed to form part of an outwash apron that was laid down in front of the continental ice sheet. They rest on the eroded surface of a body of old, blue gray till, and are capped by a thin layer of later, buff colored till, in all probability of Wisconsin age.

Now it is a notable fact that the pebbles in the sandy beds have the same fresh, almost unweathered appearance as those in the overlying till. It seems entirely probable, therefore, that the two deposits are essentially contemporaneous. Indeed, the interpretation that seems best to fit the facts is that the sandy beds were deposited in front of the advancing Wisconsin ice sheet and ultimately were overridden by it.

All the evidence tends to show that the outwash apron was laid down subaerially—the ocean level at that time being lowered presumably by reason of the storage of water in the ice sheets on the continents. It may be concluded, therefore, that the sandblast action which shaped the pebbles took place on the bare surface of the outwash plain that stretched in front of the Wisconsin ice sheet while that ice sheet was approaching its maximum extension. Perhaps it was effected by violent anticyclonal winds that were generated over the expanse of ice. (*Author's abstract.*)

Discussed by Messrs. ALDEN, F. G. WELLS, THOMPSON, STEPHENSON, and FENNER.

509TH MEETING

The 509th meeting of the Society was held at the Cosmos Club December 13, 1933, President C. N. FENNER presiding. Vice-President H. G. FERGUSON took the chair during the presentation of the presidential address: *Some magmatic problems.*

41ST ANNUAL MEETING

The 41st annual meeting was held at the Cosmos Club after the adjournment of the 509th regular meeting, President C. N. FENNER presiding. The annual report of the Secretaries was read. The treasurer presented his annual

report showing an excess of assets over liabilities of $1,336.86 on December 13, 1933. The auditing committee reported that books of the Treasurer were correct.

The results of the balloting for officers for the ensuing year were as follows: *President:* H. G. FERGUSON; *Vice-Presidents:* M. I. GOLDMAN and W. T. SCHALLER; *Treasurer:* C. WYTHE COOKE; *Secretaries:* T. B. NOLAN and W. D. JOHNSTON JR.; *Members-at-large of the Council:* G. A. COOPER, L. W. CURRIER, W. W. RUBEY, T. STADNICHENKO, and G. TUNELL. *Nominee for Vice-President of the Washington Academy of Sciences representing the Geological Society:* C. N. FENNER.

W. H. BRADLEY and T. B. NOLAN, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

New deal in forestry.—Privately owned forest lands are to be integrated with the national program for conservation and re-growth of forests, according to the recommendations of a conference held under the chairmanship of Secretary of Agriculture WALLACE. This conference brought together representatives of the U. S. Forest Service and other public agencies charged with the care of forest lands, several groups of professional foresters, the U. S. Chamber of Commerce, and the lumber and timber, pulp and paper, and naval stores industries. Their report may well be looked upon as almost an Emancipation Proclamation for the industries dependent upon forests.

"Sustained yield forest management" sums up in four words the New deal for American forests; the abandonment of forests as mines to be exhausted, the discovery of forests as "farms" to be intelligently cultivated.

The end sought, though stateable in a single simple phrase, "sustained yield," is not so simply attained. Many problems, some inherent in the nature of forests, some economic, some involving the human equation, must be solved and their answers reconciled. The conference undertook to do this, at least in outline, in such a way as to include even the individual farmers' timber lots, as well as the huge holdings of private lumber companies and the great state and National forests.

The recommendations of the conference are contained in no less than 46 sections, beginning with the combating of fire, insects, disease, and other natural forces of destruction, and carrying through to suggested sources of funds for the prosecution of new lines of research in the forests. Outstanding suggestions include; consolidation of administration of publicly owned forests, elimination of unnecessary competition in marketing between public and private forests, vigorous pursuit of the present policy of adding to public forests by purchase of new lands, adjustment of tax burdens on private forest lands to encourage rational rather than forced marketing, federal organization of credits, increased protection against fire, establishment of sound lumber specifications, increased appropriations for administration, education, and research.

C.W.A. dismissals and science.—The gradual closing up of the operation of the Civil Works Administration, which involves the dismissal of 400,000 employees at the rate of ten per cent a week until May 21, immediately

affects the scientific departments of the government as follows: The Department of Agriculture is reduced from 91,147 employees to 48,000; the Fisheries Commission from 2,349 to 650; the Bureau of Mines from 446 to 225. In addition, the Coast and Geodetic Survey must discontinue its supplementary control survey, employing about 15,030 men; the Smithsonian Institution its archaeological excavations, employing 1,104, in Florida, North Carolina and other places the one exception being the undertaking in Shiloh National Park; the Tennessee Valley Authority a large number of the 16,588 men at work on improvement projects; the Interior Department 1,762 men on soil erosion work, and the Public Health Bureau 29,779 men on malaria control work, 32,010 on rural sanitation, and 6,572 sealing mines to stop water acidity in the Ohio Valley. Projects under the Department of Agriculture which must be stopped include cattle tick eradication, involving 6,000 men; typhus-fever control operated cooperatively with the Public Health Service, 17,033 men; citrus canker control in Texas, 88; Dutch elm disease control in several New England states, 1,057; phony peach eradication, 1,112; potato weevil eradication, 211; spotted fever control, 369; mosquito pest control, 25,646, and brown-tail moth control, 5000.

National Park Service.—The name, "National Park Service," was reinstated and applied to the Office of National Parks, Buildings and Reservations, by an Act of Congress signed by President ROOSEVELT on March 2. The National Park Service was originally established in 1916 to correlate federal park administration. Its scope was expanded to include care of national buildings and reservations as well, by the consolidation of June 10, 1933, and its name changed accordingly. But the convenience and familiarity of the older and shorter name, together with a wealth of associations in the minds of many persons familiar with the excellent progress of the national parks and monuments during the administrations of the late STEPHEN T. MATHER and of his successor, HORACE M. ALBRIGHT, prevailed to bring about its restoration.

The National Park Educational Advisory Board met in Washington, D. C., on February 26 and 27. The members of the board in attendance were Dr. H. C. BUMPAS, Chairman; Dr. W. W. ATWOOD, Dr. W. W. CAMPBELL, Dr. WALDO G. LELAND, and Dr. FRANK R. OASTLER.

Many important problems relative to educational policy were passed upon. Of particular importance were reports on historical developments presented by chief historian VERNE E. CHATELAIN of the National Park Service, and a plan outlining museum development in the whole national park system presented by ANSEL F. HALL, chief of the Field Division of Education and Forestry of the National Park Service.

Bureau of Plant Industry.—The Bureau of Plant Industry, United States Department of Agriculture, has issued the first in a series of publications describing types of American varieties of vegetables. This series is intended to remedy the lack of generally accepted, authentic, and adequate descriptions of vegetables varieties, and to remove the confusion as to just what characteristics a given variety should possess. The work is based on cooperative studies by the Bureau and certain state experiment stations and is designed to present the consensus of opinion of the seedsmen, vegetable growers, canners, and horticulturists who are best qualified to judge what type should be established as a standard. The publication recently issued describes the nine principal varieties of tomatoes and contains numerous illus-

trations, some of them in color, showing plants and fruits. Similar works on cabbage and peas are in press, and others are in preparation.

World veterinary congress.—President ROOSEVELT, Secretary of Agriculture WALLACE, and a number of officers of the U. S. Department of Agriculture will cooperate with other American scientists as hosts to the Twelfth International Veterinary Congress, which will meet at the Waldorf-Astoria Hotel in New York, August 13 to 18. This is the first time this body has met in the United States, previous meetings having been held in Europe. The object of the congress is the advancement of the science and practice of veterinary medicine and surgery. Besides the presentation of papers on scientific and practical veterinary questions of world scope, the program provides for an interchange of opinions and experiences among the delegates.

FRANKLIN D. ROOSEVELT, President of the United States, is patron of the congress and HENRY A. WALLACE, Secretary of Agriculture, is vice patron. Prof. Dr. E. LECLAINCHE, director of the Bureau of Epizootics, Paris, France, is president of the permanent committee in charge of arrangements, and Dr. JOHN R. MOHLER, chief of the Bureau of Animal Industry, U. S. Department of Agriculture, is a vice-president and will present one of the principal papers. Other Department officials and scientists on the program are Dr. W. E. COTTON, Dr. A. E. WIGHT, Dr. M. DORSET, Dr. M. C. HALL, Dr. E. C. JOSS, all of the Bureau of Animal Industry.

NEWS BRIEFS

So strong was the Utah earthquake of March 12 that it was registered on instruments at the U. S. Coast and Geodetic Survey observatory at Cheltenham, Md., which are primarily intended for recording of the magnetic field of the earth. For ten minutes at the time of the main shock the magnetic needle wrote a record of the earth tremors and in the afternoon another shock set them in motion for eight minutes.

A new trap developed by W. D. REED of the U. S. Department of Agriculture functions efficiently against the cigarette beetle, one of the most destructive enemies of stored tobacco.

The first joint meeting of the Institute of Radio Engineers and the American Section of the International Scientific Radio Union has been announced, to be held in Washington on April 27.

The Smith-Reed-Russell lecture for March at the School of Medicine, George Washington University, was given by Dr. JOHN WHEELER, professor of ophthalmology in Columbia University and director of the ophthalmological Institute. Dr. WHEELER spoke on *Exophthalmos*.

In a statement issued on February 22, members of President Roosevelt's Science Advisory Board strongly condemned the oft-repeated declaration that "science destroys jobs," asserting that on the contrary research opened the way to more and pleasanter employment opportunities.

A C.W.A. worker in the Smithsonian Institution library discovered in a German book printed within twenty years after Columbus' death a most unconventional description of the great navigator: it characterized him as big, brave, and sharp-eyed, and said he had a "long, red, freckled face." The book is now being translated into English.

The third Arthur lecture was given on the evening of February 26 by Dr. CHARLES G. ABBOT, secretary of the Smithsonian Institution. Dr. ABBOT spoke on *How the sun warms the earth.*

The discovery of an important center of Maya civilization, bridging a gap between Old Empire and New Empire cultures, was announced on February 24 by the Carnegie Institution of Washington.

"Heavy water" accumulates in willow shoots, apparently through differential evaporation, researches by the late Dr. EDWARD W. WASHBURN and his associate Dr. EDGAR B. SMITH of the National Bureau of Standards, indicate. Their paper was published in *Science.*

The following radio talks were given under the auspices of Science Service, over the network of the Columbia Broadcasting System: February 28, Dr. FRANK LORIMER, *Population trends of American groups;* March 7, Dr. WALTER T. SWINGLE, U. S. Department of Agriculture, *New crops for the American Sahara.*

PERSONAL ITEMS

JAY N. DARLING of Des Moines, Iowa, has been appointed chief of the Bureau of Biological Survey, U. S. Department of Agriculture. Although he is known to the public chiefly as one of the outstanding cartoonists of the world, Mr. DARLING has also been for many years an enthusiastic and careful student of wild life and a strong conservationist. PAUL G. REDINGTON, whom Mr. DARLING succeeds in office, was transferred at his own request to the Forest Service on March 1. Previous to his appointment as chief of the Biological Survey seven years ago, Mr. REDINGTON had been for twenty-three years with the Forest Service.

G. H. BARNES of the Canadian Forest Service, on a three-months' detail in Washington, with FRANCIS X. SCHUMACHER of the Branch of Research, U. S. Forest Service, is making a study of methods of predicting growth in the uneven-aged spruce forests after partial cutting.

Dr. JOHN C. MERRIAM, president of the Carnegie Institution of Washington, read a paper on *Conservation and evolution in a changing social program* before a stated meeting of the American Philosophical Society in Philadelphia on March 2.

Prof. W. H. TWENHOFEL of the University of Wisconsin, chairman of the division of geology and geography, National Research Council, has been elected chairman of the Tri-State Geological Field Conference of Wisconsin, Iowa, and Illinois.

Dr. WALTER C. LOWDERMILK of the California Forest Experiment Station, Berkeley, has been appointed vice-director of the Soil Erosion Service of the U. S. Department of the Interior.

Lieut.-Comdr. T. G. W. SETTLE, U.S.N., spoke on February 8 before the Physics Club of the University of Chicago on *The physics of free ballooning.*

H. H. NININGER, curator of meteorites at the Colorado Museum of Natural History, spoke before the Cosmos Club on the evening of February 19.